UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

MEMORANDUM

June 20, 2000

SUBJECT: Occupational/Residential Handler and Postapplication Residential/Non-Occupational Risk Assessment for Chlorpyrifos. DP Barcode: D266562. Case No. 818975. PC Code: 059101. Submission: S568580

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1.0 EXECUTIVE SUMMARY

This document contains the occupational and residential exposure assessment for chlorpyrifos, resulting from the residential uses of chlorpyrifos products. Exposures are evaluated for occupationally-exposed Pest Control Operators (PCOs) and Lawn Care Operators (LCOs) at residential sites, residents who apply chlorpyrifos products, and residential populations that may be exposed following pesticide application. Some products containing chlorpyrifos are intended primarily for homeowner use, while some are intended primarily or solely for PCO/LCO use. This memorandum addresses non-agricultural uses, focusing on residential sites. Agricultural, ornamental and animal premise uses are addressed elsewhere (memorandum from T. Leighton to D. Smegal, DP Barcode D263893, June 2000).

Chlorpyrifos is an organophosphate insecticide used extensively in residential settings by both residents and PCOs. Chlorpyrifos' most common trade names are Dursban, Empire 20, Equity, and Whitmire PT 270. It is one of the top five insecticides used in residential settings. There are approximately 822 registered products containing chlorpyrifos on the market (REFs 9/14/99). Registered uses include a wide variety of food, turf and ornamental plants, as well as indoor product use, structural pest control, and in pet collars. It is used in residential and commercial buildings, schools, daycare centers, hotels, restaurants, hospitals, stores, warehouses, food manufacturing plants and vehicles. In addition, it is used as an adult mosquitocide. In 1998, Dow AgroSciences (DAS) estimated that 70% of the urban chlorpryifos use involved termite control. Approximately 11 million pounds are applied annually in non-agricultural settings (i.e., residences, schools, golf courses, parks) in the U.S.

In June 1997, the registrants of chlorpyrifos voluntarily agreed to measures designed to reduce household exposure to chlorpyrifos, as part of a risk reduction plan. This voluntary plan included deletion of indoor broadcast use, use as an additive to paint, direct application to pets (sprays, shampoos and dips), and indoor total-release foggers. The technical chlorpyrifos products have been amended to reflect the negotiated plan. The technical label limits end use product labeling to only those sites which are specified on its label. In addition, the registrants have implemented measures to improve education, training, and labels, and report and analyze incidents. In addition, as part of this agreement, the registrants agreed to work with EPA to develop broad, market-wide policies for all indoor insecticides for a number of areas.

EPA and the registrants have agreed to certain modifications to the use of chlorpyrifos to mitigate dietary, worker and residential risks. This risk assessment incorporates elements of this agreement in a number of its analyses in order to characterize post-mitigation risks. The agreement includes:

Non-Agricultural Uses

- Cancel all indoor residential uses (except fully contained ant baits in child resistance packaging).
- Cancel all outdoor residential uses (except limited public health uses).
- Cancel all indoor and outdoor non-residential uses except:

- Use on golf courses
- Limited public health uses
- Limited use in industrial settings (e.g. manufacturing plants, ship holds)
- Cancel whole house “post-construction” termiticide use.
- Phase out limited post-construction spot and local termiticide treatments
- Phase out pre-construction termiticide treatments
- Reduce the maximum application rate for phased-out termiticide treatments to a 0.5% concentration.
- Reduce the maximum application rate for use on golf courses to 1 lb. active ingredient per acre.

Chlorpyrifos, O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate, is an insecticide formulated as a wettable powder (containing 50% a.i.), emulsifiable concentrates (41.5-47%), dust (containing 0.1-7% a.i.), granular (containing 0.075%-2.5% a.i.), bait (containing 0.5% a.i.), flowables (containing 30% a.i.), impregnated material (containing 0.5-10% a.i.), pelleted/tableted (containing 0.5-1.0% a.i.), pressurized liquids (0.9-3.8% a.i.), and microencapsulated (0.5-20% a.i.). According to DAS, wettable powders packaged in open bags and dry flowables are no longer available and are being removed from active registrations. They are not assessed in this chapter and are no longer eligible for re-registration. The Agency will work with DAS to delete any other formulations and/or products that are obsolete.

Dow AgroSciences' states that formulations with concentrations greater than one pound a.i. per gallon (approximately 13% a.i.) are sold only to pest control or turf and ornamental professionals. Lower concentrations are available to homeowners from other suppliers for over-the-counter purchase. Except aerosols, granules and dusts, all formulated end-use products for application are diluted in water to a concentration of 1 percent a.i. or less (Dow AgroSciences 1998). However, HED is aware of at least one company that sells concentrated chlorpyrifos products (i.e., >13% up to 44.8% a.i.) to the public on the Internet (www.ADDR.com\~pestdepo\gizhome.html) as of March 1, 2000.

The toxicity endpoints used in this document to assess hazards include short-, intermediate- and long-term dermal and inhalation endpoints, and the acute oral endpoint. A route-specific short-term dermal no-observed adverse effect level (NOAEL) of 5 mg/kg/day from a 21-day dermal rat study has been identified based on plasma and red blood cell (RBC) cholinesterase (ChE) inhibition of 45% and 16%, respectively at 10 mg/kg/day (the lowest observed adverse effect level, LOAEL). Therefore, a dermal absorption adjustment is not necessary. The intermediate- and long-term dermal NOAEL is converted from an oral NOAEL of 0.03 mg/kg/day from a weight of the evidence from 5 oral studies in dogs and rats using a 3 percent dermal absorption factor. Plasma and RBC ChE inhibition occurred in these studies at dose levels of 0.22 to 0.3 mg/kg/day. Dermal absorption was estimated to be 3 percent based on the ratio of the oral lowest-observed-adverse effect level (LOAEL) of 0.3 mg/kg/day from the rat developmental neurotoxicity study (MRID Nos. 44556901, 44661001) to the dermal LOAEL of 10 mg/kg/day from the 21-day dermal study (MRID No. 40972801) for plasma and red blood cell cholinesterase inhibition. This absorption factor is comparable to the dermal absorption estimated from human data of 1-3% (MRID No. 00249203).

The short- and intermediate-term inhalation NOAEL is 0.1 mg/kg/day from two separate 90-day rat inhalation studies that did not observe effects at the highest dose tested. At higher oral doses of 0.3 mg/kg/day(LOAEL), 43% plasma and 41% RBC ChE were observed in animals. The lung absorption is assumed to be 100 percent of oral absorption. The long-term inhalation NOAEL is converted from an oral NOAEL of 0.03 mg/kg/day from the 5 oral studies in dogs and rats, assuming that inhalation and oral absorption are equivalent. The acute oral NOAEL is 0.5 mg/kg/day from an acute oral rat study that observed 28-40% plasma cholinesterase inhibition 3-6 hours after dosing male rats with a single dose of 1 mg/kg/day (memorandum from D. Smegal to S. Knizner, April 6, 2000, HED Doc number 014088). The acute oral NOAEL was used to assess short-term exposures resulting from incidental ingestion (i.e., hand to mouth exposures) of less than one week for children. This is considered appropriate because exposures and risks are calculated for the day of application, when residential exposures are expected to be greatest. Oral exposure was not evaluated for workers. The exposure duration for short-term assessments is 1 to 30 days. Intermediate-term durations are 1 to 6 months, and long-term exposures are durations greater than six months.

For the dermal and inhalation risk assessments, risk estimates are expressed in terms of the Margin of Exposure (MOE), which is the ratio of the NOAEL selected for the risk assessment to the exposure. For occupationally exposed workers, MOEs > 100 (i.e., 10x uncertainty factor for interspecies extrapolation and 10x uncertainty factor for intraspecies variability) do not exceed HED's level of concern. For residential populations, MOEs > 1000, which includes an additional 10x Food Quality Protection Act (FQPA) safety factor do not exceed HED's level of concern. It was assumed that all residential handlers are female.

Multiple exposure studies were conducted by the registrant and submitted to the Agency that evaluate exposures to PCOs/LCOs/residential handlers and residents following application of chlorpyrifos products. These data include biological monitoring, passive dosimetry and environmental measurements. These data, along with supplemental data from the Pesticide Handlers Exposure Database (PHED) Version 1.1, were used to assess potential PCO/LCO exposures resulting from handling and applying chlorpyrifos in residential settings. Postapplication residential exposures were assessed using primarily the registrant-submitted data. In the absence of data, the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments (December 18, 1997), in addition to assumptions for the updated SOPs to be released in 2000, many of which were presented the to the FIFRA Scientific Advisory Panel (SAP) in September 1999, were used to estimate exposures. Exposures associated with all uses of chlorpyrifos products have not been monitored. Therefore, the available data were used to evaluate similar uses (i.e., lawn studies used to evaluate yard and ornamental sprays, residential crack and crevice exposure data used to evaluate similar treatments in other buildings such as schools, day care centers, the workplace, etc).

HED is in the process of revising the residential exposure assessment SOPs. This process may identify specific areas of further concern with respect to chlorpyrifos and exposure to the general population. For example, some of the secondary exposure pathways that EPA will be addressing include exposures resulting from residue tracked into homes from outdoor use, indoor dust, and spray drift. In a recent study, polycyclic aromatic hydrocarbons (PAHs) that are abundant in house dust were shown to increase the toxicity of chlorpyrifos in vitro, particularly at low levels (i.e., 2-50 μM PAHs with 1-180 nM chlorpyrifos-oxon, a metabolite of chlorpyrifos that inhibits acetyl cholinesterase) (Jett et al. 1999).

HED has concerns for the potential for children's exposure in the home as a result of residential and/or agricultural uses of chlorpyrifos. Environmental concentrations of chlorpyrifos in homes may result from residential uses, spray drift, track-in, or from redistribution of residues brought home on the clothing of farm workers or pesticide applicators. Potential routes of exposure for children may include incidental ingestion and dermal contact with residues on carpets/hard surfaces, in addition to inhalation of vapor and airborne particulates. There are several literature studies that quantify the levels of chlorpyrifos in household dust, indoor and outdoor air, dermal wipe (hands) and soil samples. These residues may persist and the resulting exposures are of a potential chronic nature. Currently, there are no SOPs available to evaluate potential exposures from spray drift and track-in. These scenarios however, may be evaluated in the future pending revisions to the residential SOPs.

As noted previously, there are more than 800 currently registered products containing chlorpyrifos. HED believes the most significant uses and exposures have been evaluated in this assessment. Nevertheless, there is insufficient use information and exposure data to assess exposure resulting from a number of chlorpyrifos uses, including use in vehicles (i.e., planes, trains, automobiles, buses, boats) and other current label uses such as treatment of indoor exposed wood surfaces, supermarkets, restaurants, theaters, playhouses, furniture, and draperies, etc. HED has concern for these and other registered uses based on the scenarios assessed within this document, which show that nearly all the current uses evaluated result in MOEs that exceed HED's level of concern for children and/or adult residents. Therefore, HED requests exposure data for all registered product uses not evaluated in this assessment.

Risk and Uncertainty Characterization

Occupational/Residential Handler Risks

The following scenarios result in MOEs that exceed HED's level of concern (i.e., MOE less than 100 and 1000 for occupational and residential pesticide handlers, respectively):

- Indoor Crack and Crevice Treatment by a PCO and residential applicator;
- Broadcast Turf Treatment by a LCO (intermediate and long-term applicator, mixer/loader) and short-term residential mixer/loader/applicator;
- Spot Treatment of Turf by a residential mixer/loader/applicator;
- Golf Course Treatments by workers (maximum label rate of 4 lb ai/acre for: mixer/loaders of liquids, and mixer/loaders and applicators for greens and tees) and typical and maximum label rates of 1 and 4 lb ai/acre for groundboom applicators);
- Ready-to-Use Formulated product (Ant Stop) containing 0.5% ai chlorpyrifos (residential handler);
- Application of Insecticidal Dust Products by a PCO and residential applicator;
- Application of Granular Formulations by a LCO and residential applicator (by hand, belly

grinder or push-type spreader);
- Termiticide Treatments for Pre-Construction by a PCO;
- Termiticide Treatments for Post-Construction by a PCO;
- Paintbrush Applications by a residential applicator;
- Ornamental Application by a residential mixer/loader/applicator, and
- Mosquitocide mixer/loader or applicator for aerial applications of more than 30 days, even with engineering controls

The following scenarios result in MOEs greater than 100 that do not exceed HED's level of concern for occupational pesticide handlers:

- Mixer/loader of liquid lawn care products wearing PPE (LCO)(total MOEs 100-820);
- Golf Course Treatments by workers (typical label rate of 1 lb ai/acre for: mixer/loaders of liquid and wettable powders, and mixer/loaders and applicators for greens and tees; maximum label rate of 4 lb ai/acre for mixer/loaders of wettable powders) (total MOEs 100-400),
- Workers who mix/load or apply chlorpyrifos for aerial mosquitocide applications of less than 30 days with the use of engineering controls (closed systems)(total MOEs 160-240); and
- Workers who mix/load or apply chlorpyrifos for ground-based fogger mosquitocide applications up to several months with the use of PPE and/or engineering controls (total MOEs 100-560).

The results of the PCO/LCO handler assessment in residential/recreational settings for short, intermediate and/or long-term exposure scenarios indicate that most of the MOEs are less than 100, and therefore exceed HED's level of concern. Only the four scenarios listed above have total MOEs above 100, and therefore, do not exceed HED’s level of concern. Exposures for four of the scenarios were estimated based on chemical-specific biomonitoring studies submitted by Dow AgroSciences (i.e., indoor crack and crevice treatment, broadcast turf application, and pre- and post-construction termiticide treatment) in which the PCOs wore label-specified personal protective equipment (PPE) or PPE in addition to that specified on the labels. Several of these studies did not represent the maximum label application rates, or only evaluated exposures for a few hours (i.e. 1-3 hours) of the work day, and consequently could underestimate exposures and risks to PCOs. Overall, the exposures and risks for LCOs/PCOs based on the chemical-specific biomonitoring studies are considered to be central tendency estimates because they evaluated less than a full day's exposure at the maximum label rate or they exclude accidental exposure (e.g., exposure resulting from a broken hose). In the absence of chemical-specific data, LCO/PCO exposures were estimated using data from PHED or the Draft Residential SOPs (12/18/97). The PHED data used for the mixer/loader for lawn treatment, and granular application (hand, belly grinder and push-type spreader) scenarios are representative of the chlorpyrifos uses as the surrogate data were monitored for similar scenarios. For example, granular bait was hand applied (with chemical-resistant gloves) to driveways and sidewalks; granulars were applied with a belly grinder to driveways and turf, and the push-type granular spreader was used on a lawn.

The results of the residential handler assessment for short- term exposure scenarios indicate that all nine of the scenarios evaluated have total MOEs that exceed HED's level of concern defined by a target MOE of 1000. The residential handler MOEs ranged from 3 to 900 for dermal risk, from 120 to 57,000 for inhalation risk, and from 3 to 880 for total risk for the maximum, typical and even minimum label-recommended use rates. For a number of scenarios, multiple evaluations were conducted using application rates less than the maximum label rate, or application using different equipment or methods (i.e., ornamental treatment via low pressure hand wand and hose-end sprayer, and granular application via hand, belly grinder and push-type spreader) to provide information for risk mitigation and management decisions. MOEs for a few products evaluated at the minimum application use rate were greater than 1000 (i.e., crack and crevice spot treatment had a MOE of 1600), and therefore do not exceed HED's level of concern. Due to an absence of chemical-specific homeowner applicator studies, the majority of residential applicator exposures were estimated based on the data from the Draft Residential SOPs (December 1997) or updated assumptions for the SOPs to be released in 2000 (i.e., indoor crack and crevice treatment, broadcast turf application, granular formulation application, paintbrush application, and treatment of ornamentals). In all cases, it was assumed that residents wore short pants, short sleeves, and no gloves, in accordance with current Agency policy. Only one of the residential handler scenarios (outdoor ready to use product) was evaluated using chemical-specific data submitted by Dow AgroSciences. Dow AgroSciences has not submitted any other residential handler exposure data. The remaining scenarios were evaluated using the Residential SOPs or PHED.

<u>Postapplication Residential/Worker Risks</u>

The following scenarios result in MOEs less than 1000, or potential exposures that exceed HED's level of concern:

- Broadcast Turf Treatment Using a Liquid or Granular Formulation;
- Yard Sprays;
- Indoor Crack and Crevice Treatment;
- Pet Collar Products;
- Termiticide Treatments for Basement, Plenum, Slab and Crawlspace Construction Homes,
- Golf Course Use (adolescent and adult golfer) following treatment at the maximum rate of 4 lb ai/acre, and
- Perimeter treatments of Residences.

While the following scenarios result in MOEs greater than 100 or 1000 that do not exceed HED's level of concern for postapplication worker and residential exposures, respectively:

- Golf Course Use (adolescent and adult golfer) following treatment at the typical rate of 1 lb ai/acre;
- Aerial and ground-based fogger adult mosquitocide application, and
- Golf course mow/maintenance workers.

The results of the residential/worker postapplication exposure scenarios indicate that seven of the nine scenarios evaluated have MOEs that are less than 1000, and therefore exceed HED's level of concern. In addition, for post application exposure to children following perimeter applications to homes, it was estimated that more than seven hand-to-mouth events or more than 8 minutes of play on treated turf the day of treatment could result in potential exposures that could exceed the Agency's level of concern (i.e., MOE < 1000). MOEs that exceed HED's level of concern ranged from 6 to 980 for total risk. The only residential/recreational scenarios that resulted in MOEs above 1000 were adolescent and adult golfers for the typical application rate of 1 lb ai/acre (MOEs 1500-2400) and exposures from the aerial and ground-based fogger adult mosquitocide applications (MOEs are 15,000-43,000). In addition, the short-term MOEs for post application exposures for mow/maintenance workers at golf courses are above 100 (110 to 210) and therefore, do not exceed HED's level of concern, even at the maximum label rate of 4 lb ai/acre. Several of the residential postapplication exposures were estimated based on chemical-specific studies submitted by Dow AgroSciences (i.e., crack and crevice treatment of the kitchen and bathroom, broadcast treatment of turf with chlorpyrifos spray and granules, and termiticide treatment). The exposure and risk estimates based on the chemical-specific studies are considered to be reasonable estimates (i.e., arithmetic average, or median exposure was used to calculate risk). Because these studies were conducted in adults, conservative assumptions were used to estimate child exposures. However, because adult activity patterns differ from children, i.e., hand-to-mouth activity, some of the registrant-submitted chemical-specific studies could under-estimate a child's exposure (e.g., lawn studies are not designed to reflect any potential for incidental ingestion of residues from treated turf, soil and/or granules). In the absence of chemical-specific data, exposures were estimated based on data from the Draft Residential SOPs or updated assumptions from the SOPs to be released in 2000 (i.e., indoor crack and crevice treatment, and pet collar uses). Scientific literature studies, the AgDrift Model and the Draft Residential SOPs were used to evaluate adult mosquitocide uses.

No data are available to evaluate the postapplication residential exposures and risks associated with the use of insecticidal dust products indoors. In addition, there are no recommended procedures for evaluating these products in the Residential SOPs. Nevertheless, HED has concerns about the use of these products based on the low MOEs calculated using a study in the scientific literature (based on a carbaryl dust product that was used as a surrogate for chlorpyrifos) for residents or workers that could apply these products. HED recommends that the registrant provide additional information on the potential postapplication residential exposures associated with these products.

HED requests additional data for indoor crack, crevice and spot uses of chlorpyrifos. Specifically, HED requests treated room residue data for floors, furniture and other surfaces available for contact by children for both chlorpyrifos, and its primary degradation metabolite, 3,5,6-TCP following multiple treatments. Additionally, to chlorpyrifos air measurements are also required in treated rooms following multiple treatments (i.e., at a minimum 3 treatments 7 days apart). Residue data for 3,5,6-TCP are important due to the potential for accumulation and persistence of this environmental degradate.

HED requests confirmatory air monitoring data immediately following mosquito ground-based fogger or application due to potential concern for short-term inhalation exposures.

In addition, HED requests exposure and/or environmental data for all registered products and/or uses that are not assessed in this risk assessment.

2.0 BACKGROUND

Purpose

This document evaluates the potential health effects of occupational and residential exposure to chlorpyrifos, resulting from the residential uses of chlorpyrifos products. Exposures are evaluated for occupationally-exposed Pest Control Operators (PCOs), Lawn Care Operators (LCOs) residents who apply the chlorpyrifos products, and residential populations that may be exposed following pesticide application. This information will be incorporated into the Chlorpyrifos Reregistration Eligibility Decision Document (RED).

Criteria for Conducting Exposure Assessments

An occupational and residential exposure assessment is required for an active ingredient if (1) certain toxicological criteria are triggered <u>and</u> (2) there is potential exposure during use or to persons entering treated sites after application is complete. Both criteria are met for chlorpyrifos.

Summary of Toxicological Endpoints

The Hazard Identification Committee memos, dated June 2, 1999, March 4, 1999, and April 6, 2000 indicate that there are toxicological endpoints of concern for chlorpyrifos. The endpoints, and associated uncertainty factors used in assessing the risks for chlorpyrifos are presented in Table 1.

Table 1
Chlorpyrifos Hazard Endpoints, Uncertainty Factors and MOEs

EXPOSURE SCENARIO	DOSE (mg/kg/day)	ENDPOINT	STUDY	MOE for Workers	MOE for Residents
Acute Dietary (oral)	NOAEL=0.5 UF = 100 FQPA = 10 (infants, children and females 13-50)	plasma cholinesterase inhibition at peak time of inhibition (3-6 hours post exposure) at 1 mg/kg. Significant RBC ChE inhibition at 1.5 mg/kg/day	Blood Time Course Study (Mendrala and Brzak 1998) with support from Zheng et al. 2000	NR	1000 (infants, children and females 13-50)

Table 1 Chlorpyrifos Hazard Endpoints, Uncertainty Factors and MOEs					
EXPOSURE SCENARIO	**DOSE (mg/kg/day)**	**ENDPOINT**	**STUDY**	**MOE for Workers**	**MOE for Residents**
Short-Term (Dermal)	Administered Dermal NOAEL =5 Absorbed Dermal NOAEL = 0.15 (for biomonitoring) (a)	Plasma and RBC cholinesterase inhibition of 45 and 16%, respectively at 10 mg/kg/day following 4 days. (Dermal absorption factor not necessary for administered dermal NOAEL)	21-day dermal rat study	100	1000 (infants, children and females 13-50)
Intermediate- and Long-Term (Dermal)	Oral NOAEL =0.03	Plasma and RBC cholinesterase inhibition at 0.22-0.33 mg/kg/day. (Use 3% dermal absorption)	Weight of Evidence from 5 studies: 90 day and 2 year dog studies; 90 day and 2 year rat studies, and developmental neurotoxicity study	100	1000 (infants, children and females 13-50)
Short-,and Intermediate-Term (Inhalation)	Inhalation NOAEL= 0.1	Lack of effects in 2 rat inhalation studies at the highest dose tested. >40% plasma and >40% RBC cholinesterase inhibition following oral doses of 0.3 mg/kg/day (100% lung absorption assumed)	Two 90 day rat inhalation studies	100	1000 (infants, children and females 13-50)
Long-Term (Inhalation)	Oral NOAEL= 0.03	Plasma and RBC cholinesterase inhibition at 0.22-0.33 mg/kg/day (Assume inhalation and oral absorption equivalent)	Weight of Evidence from 5 studies: 90 day and 2 year dog studies; 90 day and 2 year rat studies, and developmental neurotoxicity study	100	1000 (infants, children and females 13-50)

NR = Not Relevant
UF = Uncertainty Factor
MOE = Margin of Exposure
RBC = Red blood cell
(a) Use absorbed dermal NOAEL of 0.15 mg/kg/day (5 mg/kg/day * 0.03 dermal absorption factor) for comparison with absorbed biomonitoring exposure.

As shown on Table 1, the short-term dermal NOAEL is 5 mg/kg/day from a 21-day dermal rat study, based on plasma and red blood cell (RBC) cholinesterase (ChE) inhibition of 45% and 16%, respectively at 10 mg/kg/day. Therefore, no dermal absorption factor adjustment is necessary. For comparison with biomonitoring data that represents total absorbed dose, an adjusted dermal absorbed dose of 0.15 mg/kg/day (5 mg/kg/day * 0.03 dermal absorption factor) was used because for most scenarios, the majority of exposure results from dermal exposure (See HIARC report dated April 6, 2000, HED doc no. 014088 for detailed discussion). The intermediate- and long-term dermal NOAELs and long-term inhalation NOAEL are 0.03 mg/kg/day based on weight of the evidence for plasma and RBC ChE inhibition from five oral studies in dogs and rats. Because an oral NOAEL was selected, a dermal absorption factor of 3%, and a 100% default inhalation absorption factor (i.e., inhalation and oral absorption are equivalent) were used. Dermal absorption was estimated to be 3 percent based on the ratio of the oral lowest-observed-adverse effect level (LOAEL) of 0.3 mg/kg/day from the rat developmental neurotoxicity study (MRID Nos. 44556901, 44661001) to the dermal LOAEL of 10 mg/kg/day from the 21-day dermal study (MRID No. 40972801) for plasma and red blood cell cholinesterase inhibition. This absorption factor is comparable to the dermal absorption estimated from human data of 1-3% (MRID No. 00249203).

The short- and intermediate-term inhalation NOAEL is 0.1 mg/kg/day based on lack of effects in two rat inhalation studies at the highest dose tested. At higher oral doses of 0.3 mg/kg/day >40% plasma and >40% RBC ChE were observed in animals. The acute oral NOAEL is 0.5 mg/kg/day from an acute oral rat study that observed 28-40% plasma cholinesterase inhibition 3-6 hours after dosing male rats with a single dose of 1 mg/kg/day (HIARC memorandum from D. Smegal to S. Knizner, April 6, 2000, HED doc no. 014088). The acute oral NOAEL was used to assess short-term exposures resulting from incidental ingestion (i.e., hand to mouth exposure) of less than one week. This is considered appropriate because exposures and risks are calculated for the day of application, when residential exposures are expected to be greatest.

Summary of Use Pattern and Formulation

At this time some products containing chlorpyrifos are intended primarily for residential use, while some are intended primarily or solely for PCO/LCO use. Both occupational/PCO/LCO (non-agricultural) and residential use are evaluated in this document. Agricultural uses are addressed elsewhere.

Types of Pesticide/Targeted Pest/Use Sites

Chlorpyrifos is an organophosphate insecticide used extensively in residential settings by both residents and pest control operators (PCOs). Chlorpyrifos' most common trade names are Dursban, Empire 20, Equity, and Whitmire PT 270. Lorsban is a trade name for agricultural-use products. It is one of the top five insecticides used in residential settings. There are approximately 822 registered products containing chlorpyrifos on the market (REFs 9/14/99). Approximately 20 to 24 million pounds are used annually in the U.S, with approximately 11 million pounds applied in non-agricultural settings (i.e., residences, schools, golf courses, parks). Registered uses include a wide variety of food, turf and ornamental plants, as well as indoor product uses, structural pest control, and in pet collars. It is used in residential and commercial buildings, schools, daycare centers, hotels, restaurants, hospitals, stores, warehouses, food manufacturing plants and vehicles. In addition, it is used as an adult mosquitocide. In 1998, Dow AgroSciences estimated that 70% of the urban chlorpryifos use involved termite control.

Formulation Types and Percent Active Ingredient

Chlorpyrifos, O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate, is an insecticide formulated as a wettable powder (containing 50% a.i.), emulsifiable concentrates (41.5-47%), dust (containing 0.1-7% a.i.), granular (containing 0.075%-2.5% a.i.), bait (containing 0.5% a.i.), flowables (containing 30% a.i.), impregnated material (containing 0.5-10% a.i.), pelleted/tableted (containing 0.5-1.0% a.i.), pressurized liquids (0.9-3.8% a.i.), and microencapsulated (0.5-20% a.i.). Dow AgroSciences states that formulations with concentrations greater than one pound a.i. per gallon (approximately 13% a.i.) are only for pest control on turf and ornamentals by professionals. Lower concentrations are available to homeowners from other suppliers for over-the-counter purchase. Except aerosols, granules and dusts, all formulated end-use products for application are diluted in water to a concentration of 1 percent a.i. or less (Dow AgroSciences 1998). However, HED is aware of at least one company that sells concentrated chlorpyrifos products (i.e., >13% up to 23% a.i.) to the public on the Internet (www.ADDR.com\~pestdepo\gizhome.html) as of March 1, 2000. According to DAS, wettable powders packaged in open bags and dry flowables are no longer available and are being removed from active registrations. They are not assessed in this chapter and are no longer eligible for re-registration. The Agency will work with DAS to delete any other formulations and/or products that are obsolete.

Method and Types of Equipment Used for Mixing/Loading/Applying

The Agency determines potential exposures to pesticides handlers by identifying exposure scenarios from the various application equipment-types that are plausible given the label uses. It is HED’s responsibility to assess all uses that are allowable/plausible based on the label. Therefore, in all cases, the maximum labeled rates are assessed. If these maximum rates do not reflect actual practice, then those rates should be removed from the labels. DAS has attempted to provide the Agency with a survey on actual uses (i.e., MarQuest Survey) and the Agency has included this information to the extent possible. For example, the frequency that the maximum labeled rates are used may be important information to the risk manger during the Agency’s risk mitigation phase.

- Handgun (LCO): Broadcast turf application
- Backpack/Low Pressure Handwand Equipment : crack and crevice treatment; spot treatment of turf; ornamental application
- Hose End Sprayer: Broadcast turf treatment, ornamental application
- Termite-injection equipment: subterranean termite control

- Belly-grinder equipment or a push type spreader: turfgrass
- Paintbrush: Treatment of infested wood

3.0 OCCUPATIONAL AND RESIDENTIAL EXPOSURE

3.1 Handler Exposures & Assumptions

EPA has determined that there are potential exposures to mixers, loaders, applicators, or other handlers during usual residential use-patterns associated with chlorpyrifos. Based on the use patterns and potential exposures described above, 12 PCO/LCO/residential handler exposure scenarios were identified for chlorpyrifos. It was assumed that all residential handlers are female, and therefore the additional FQPA safety factor of 10 is applicable to this population.

Mixer/loader/applicator (M/L/A) exposure data for chlorpyrifos were required for a reregistration data call in (DCI) issued September 18, 1991 during the reregistration process, since one or more toxicological criteria had been triggered. Requirements for applicator exposure studies are addressed by OPPTS 875 Series Occupational and Residential Exposure Test Guidelines (February 10, 1998). Applicator exposure data were required previously by the Agency. The Pesticide Handlers Exposure Database (PHED), Version 1.1 was used for several scenarios. In addition, studies from the scientific literature were used for other situations.

The following studies monitoring PCO/LCO/residential application of chlorpyrifos were submitted by the registrant.

- MRID No./Accession No. 40026001.   Vaccaro, J.R. (1986) Evaluation of Airborne and Whole Body Exposure of Lawn Care Specialists to Chlorpyrifos During Routine Treatment of Turf.

- MRID No. 44444801.   Vaccaro, J.R. et al. (1997). Determination of Exposure and Dose of General Pest Control Operators to Chlorpyrifos during Routine Applications of Dursban Pro® Insecticide to Crack/Crevices and Spots. November 25, 1997. Laboratory Project Study ID: HEH 785.

- MRID No. 44729401.   Barnekow, D.E, and Shurdut, B.A. (1998). Evaluation of Workers' Exposure to Chlorpyrifos During the Use of Dursban Pro® Insecticide Concentrate for Broadcast Turf Applications. November 10, 1998. Laboratory Project Study ID: HEA 97089.

- MRID No. 44739301.   Barnekow, D.E, Cook, W.L., Meitl, T.J., and Shurdut, B.A. (1999). Exposure to Chlorpyrifos Whilt Applying a Ready to Use Formulation. January 14, 1999. Laboratory Project Study ID: HEA 97046.

- MRID No. 44729402.   Barnekow, D.E, and Shurdut, B.A. (1998). Evaluation of Workers' Exposures to Chlorpyrifos During the Use of Dursban® TC Termiticide Concentrate for Post-Construction Termiticide Applications. October 9, 1998 (original) and December 22, 1998 (amended). Laboratory Project Study ID: HEA 97054.

- MRID No. 44589001. Murphy, P.G., Beard, K.K., Chambers, D.M., Huff, D.W., Marino, T.A., Melichar, M., and Vaccaro, J.R. (1997). Evaluation of Workers' Exposures to Chlorpyrifos During the Use of Dursban® TC Termiticide Concentrate for Pre-Construction Termiticide Applications. December 15, 1997.

HED reviewed each of these studies and used the registrant-submitted data to estimate exposures to handlers/PCOs/LCOs applying chlorpyrifos-products in residential settings. A brief summary of each study is provided below, with reference to HED's memorandum that provides a more detailed review and analysis of the study. It should be noted that a number of the registrant-submitted studies conducted biomonitoring by measuring urinary concentrations of the primary chlorpyrifos metabolite 3,5,6-trichloro-2-pyridinol (3,5,6-TCP), to estimate chlorpyrifos exposures. Prior to the studies, baseline urinary 3,5,6-TCP concentrations were determined in the study volunteers, and these baseline measurements were subtracted from the exposure-related 3,5,6-TCP concentrations measured in the biomonitoring study. It is important to note that most individuals in the U.S., and nearly all the subjects in the Dow AgroSciences biomonitoring studies had low levels of urinary 3,5,6-TCP prior to study commencement, indicating a baseline exposure to chlorpyrifos, chlorpyrifos methyl or their metabolite/degradate 3,5,6-TCP.

In the absence of chemical-specific monitoring data, data obtained from PHED Version 1.1 were used to assess handler exposures. PHED was designed by a task force of representatives from the U.S. EPA, Health Canada, the California Department of Pesticide Regulation, and member companies of the American Crop Protection Association. PHED is a software system consisting of two parts--a database of measured exposure values for workers involved in the handling of pesticides under actual field conditions and a set of computer algorithms used to subset and statistically summarize the selected data. Currently, the database contains values for over 1,700 monitored individuals (i.e., replicates).

Users select criteria to subset the PHED database to reflect the exposure scenario being evaluated. The subsetting algorithms in PHED are based on the central assumption that the magnitude of handler exposures to pesticides are primarily a function of activity (e.g., mixing/loading, applying), formulation type (e.g., wettable powders, granulars), application method (e.g., aerial, groundboom), and clothing scenario (e.g., gloves, double layer clothing).

Once the data for a given exposure scenario have been selected, the data are normalized (i.e., divided by) by the amount of pesticide handled resulting in standard unit exposures (milligrams of exposure per pound of active ingredient handled). Following normalization, the data are statistically summarized. The distribution of exposure values for each body part (e.g., chest, upper arm) is categorized as normal, lognormal, or "other" (i.e., neither normal or lognormal). A central tendency value is then selected from the distribution of the exposure values for each body part. These values are the arithmetic mean for normal distributions, the geometric mean for lognormal distributions, and the median for all "other" distributions. Once selected, the central tendency values for each body part are composited into a "best fit" exposure value representing the entire body.

The unit exposure values calculated by PHED generally range from the geometric mean to the median of the selected data set. To add consistency and quality control to the values produced from this system, the PHED Task Force has evaluated all data within the system and has developed a set of grading criteria to characterize the quality of the original study data. The assessment of the data quality is based on a number of observations and the available quality control data. While data from PHED provide the best available information on handler exposures, it should be noted that some aspects of the included studies (e.g., duration, acres treated, pounds of active ingredient handled) may not accurately represent labeled uses in all cases. HED has developed a series of tables of standard unit exposure values for many occupational scenarios that can be utilized to ensure consistency in exposure assessments. This surrogate exposure guide serves as the basis for this assessment. Best available grades are assigned to the unit exposures as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High	=	grades A and B and 15 or more replicates per body part;
Medium	=	grades A, B, and C and 15 or more replicates per body part; and
Low	=	grades A, B,C, D and E or any combination of grades with less than 15 replicates.

There are three basic risk mitigation approaches considered appropriate for controlling occupational exposures. These include the use of engineering controls, administrative controls, and the use of personal protective equipment (PPE). Engineering controls are recommended for occupational hazards wherever feasible, because they have the least continual human implementation or intervention necessary in achieving decreased exposure levels. Occupational handler exposure assessments are typically completed by HED using a baseline exposure scenario and, if required, increasing levels of risk mitigation (PPE and engineering controls) to achieve an appropriate margin of exposure. The baseline clothing ensemble for occupational exposure scenarios is generally an individual wearing long pants, a long-sleeved shirt, no chemical-resistant gloves (there are exceptions pertaining to the use of chemically-resistant gloves, footwear and aprons and these are noted), and no respirator. The first level of mitigation generally applied is PPE. As reflected in the calculations that follow, PPE may involve the use of an additional layer of clothing, chemical-resistant gloves, and/or a respirator. The next level of mitigation considered in assessing exposure and risk is the use of appropriate engineering controls which, by design, attempt to reduce or eliminate the potential exposure. Examples of commonly used engineering controls include enclosed tractor cabs, closed mixing/loading/transfer systems, and water-soluble packets. [Note: Administrative controls may include methods such as lowering application rates for handler exposure scenarios.]

For chlorpyrifos, a typical baseline scenario was not evaluated for PCOs/LCOs because it was assumed they would, at a minimum, require the label-specified PPE, in accordance with current label requirements.

Occupational/Residential Handler Exposure/Risk Assessment

The following 13 PCO/LCO/residential application scenarios were considered:

(1) Indoor Crack and Crevice or Spot Application

Commercial Applicator (MRID No. 44444801)

The registrant submitted a passive dosimetry study that characterizes exposures to professional pest control operators (PCO) during application of 0.29% Dursban Pro® (EPA Reg No. 62719-166) on cracks, crevices, and spot treatment of residential and commercial buildings. The equipment used for spraying the product was a 2-gallon, hand pressurized B&G sprayer. A total of ten professional male PCOs from three state-wide and local pest control companies were evaluated. Five of the ten volunteers performed a second replicate for a total of fifteen replicates. Each volunteer was dressed in long cotton underwear, a cotton overall with long sleeves and long pant legs, cotton socks, chemically-resistant shoes and protective gloves during the mixing process. Eye protection was used by the PCOs when chlorpyrifos was sprayed overhead. HED evaluated this study in DP Barcode 241777 and D241838 (Memorandum from D. Smegal to M. Hartman, April 19, 1999).

Dermal exposure was quantified using passive dosimetry (long cotton underwear, cotton coveralls with long sleeves and long pant legs, and cotton socks; hand washes; and head patches). Inhalation exposure was measured using a personal air pump attached to the test subject's belt. The pump was connected with a cassette containing a polyvinyl chloride filter and a cellulose support pad (37-mm diameter, 0.8-µm pore size) followed by a Chromosorb 102 vapor collection tube to evaluate inhalation exposures in the breathing zone of workers.

The amount of active ingredient (ai) handled per replicate ranged from 0.09 g to 31.04 g (mean = 9.20 g; S.D. = 9.77 g). The volume applied per replicate ranged from 0.02 gallons to 2.8 gallons (mean = 0.84 gal.; S.D. = 0.81 gal.). The sampling time per replicate ranged from 248 to 591 minutes (mean = 378 minutes). Of the sampling time, 2.3 percent (12 minutes) to 43 percent (154 minutes) was used for actual spraying activities (mean = 21 percent, or 76 minutes).

The data were used to estimate dermal and inhalation unit exposures (μg/ lb ai) based on the worker-specific amount handled (lb ai) per day, and the worker-specific total dermal or inhalation exposure based on the dosimetry measurements. The mean absorbed dermal (adjusted for 3% dermal absorption) and inhalation unit exposures of 1790 and 532 μg/lb ai, respectively were then used to calculate the total dermal and inhalation doses for three scenarios (average, minimum and maximum) based on the range of chlorpyrifos (lb ai) handled by the PCOs during the 15 replicates. The amount (lb ai) handled per worker varied significantly and ranged from 0.0002 to 0.0684 lb ai, with a mean of 0.02 lb ai. All exposures were normalized to a 70 kg body weight in accordance with HED policy for passive dosimetry measurements.

A summary of the dermal and inhalation dose estimates are presented on Table 2. The dermal dose estimates were already adjusted for 3% dermal absorption. Because dermal and inhalation unit exposure data sets are lognormally distributed, the current HED policy is to use the geometric mean for assessing exposure. As shown on Table 2, the total dermal absorbed dose ranges from 0.005 to 1.75 μg/kg/day, with a geometric mean of 0.51 μg/kg/day. The dose estimates resulting from inhalation range from 0.0015 to 0.52 μg/kg/day, with a geometric mean of 0.15 μg/kg/day. This study demonstrates that on average 71% of the total exposure (i.e., absorbed dose) to PCOs during crack and crevice treatment results from dermal exposure, while inhalation exposure contributes on average approximately 29% of the total dose. The dose estimates from this study were used to assess long-term exposures to a PCO.

The exposure data partially meet the criteria specified in Subdivision U (currently referred to as Series 875 Group A). There is a large variation in the results, due primarily to the large range of chlorpyrifos ai handled (0.09 to 31.04 g), volume applied per replicate (0.02 to 2.8 gallons), sampling time (248 to 591 minutes or 4 to 9.85 hours), spray time (12 to 154 min) and percent chlorpyrifos handled (0.05 to 0.53%). In fact, only two of the fifteen replicates reflect the maximum recommended label concentration of 0.5% chlorpyrifos; an average of 0.29% chlorpyrifos was handled by the fifteen PCOs. In addition, it is possible that different tasks/activities associated with pesticide application in residential and commercial locations contributed to the range of exposures. However, the impact of applicator activities can not be determined due to an absence of study details. Despite the limitations, the data collected in this study are of sufficient scientific quality to be used in the RED document.

Residential Application

In the absence of chemical-specific data, short-term doses to residents that could treat their homes with a crack and crevice product in an aerosol can were evaluated using data from PHED V1.1, and the Residential SOPs (12/18/97). It was assumed that a residential applicator would wear short-sleeves, short pants and no gloves, that an average applicator weighs 70 kg, and applies the entire contents of a 16 ounce aerosol can that contains 1% ai chlorpyrifos (w/w, 0.16 oz or 4.5 g) (EPA Reg. 026693-00003) as a high end estimate for a heavy infestation, and the application of a 16 oz can of a 0.5% ai chlorpyrifos (EPA Reg 239-2619) to represent a lesser concentration. In addition, an assessment was conducted for a spot treatment, where a homeowner could apply 2 oz of a 0.5% ai product. The estimated doses are presented in Table 2. There is medium confidence in the dermal and inhalation unit exposure estimates from PHED, which are based on 30 dermal replicates of ABC grades, 15 hand replicates of grade A, and 30 inhalation replicates of grade ABC. The representativeness of the PHED data are excellent, as the surrogate study monitored exposures resulting from an insecticide aerosol can while treating baseboards in a kitchen.

(2) Broadcast Turf Application (MRID No. 44729401

LCO Applicator Exposures

Exposure estimates were derived from a chemical-specific Dow AgroSciences study in which workers were monitored during commercial lawn care application. HED evaluated this study in DP Barcode D252357 (Memorandum from D. Smegal to M. Hartman, April 15, 1999). This study characterizes exposures to lawn care operators (LCOs) that apply an average of 183 gallons of 0.12 percent diluted Dursban Pro (EPA Reg No. 62719-166) at a nominal rate of 1 lb ai/acre by broadcast applications to turf for an average of 6 hours (range of 4.4-8.2 hours). The actual spray time ranges from 66 to 171 minutes (average 1.5 hours). Exposures were estimated based on both dosimetry measurements and biomonitoring of urinary 3,5,6-TCP (the primary metabolite of chlorpyrifos). The study examined exposures to 15 lawn care insecticide applicators from two different companies in Ohio, that each treated 11-15 turf blocks (one block equals approximately 6,500 ft^2). The total area of treated turf ranged from 74,740 to 97,500 square feet (mean of 95,983 ft^2 or approximately 2.2 acres), while the total amount of chlorpyrifos handled ranged from 1.57 to 2.95 lb ai chlorpyrifos (mean of 2.17 lb ai). In addition, the workers unloaded and reloaded the hose following application to each lawn (i.e., repeated 15 times per replicate). This study does not characterize exposures associated with mixing and loading the insecticide. It was assumed that lawn care professionals could treat lawns for both intermediate and long term durations.

Each LCO wore pre-laundered cotton coveralls, a pre-laundered cotton socks, cotton briefs, and cotton T-shirts (undergarment); and a hat with affixed denim patches. At the end of the application, these dosimeters were collected from each applicator. The coverall and undergarments were sectioned into pieces representing arm, leg, and torso regions. Patches were affixed to the hat to serve as a surrogate for face, head and neck exposure. In addition, each LCO wore chemically-resistant nitrile gloves and knee high chemically-resistant boots (note that knee-high boots are not required by the label). Inhalation exposure was assessed through the use of personal air sampling pumps.

The total absorbed doses estimated from dosimetry range from 0.21 to 2.24 µg/kg/day, with a mean of 0.88±0.62 µg/kg/day. Approximately 33 percent of the absorbed doses resulted from inhalation and 67 percent from dermal exposure. The total absorbed dose estimated from biomonitoring ranged from 0 to 4.84 µg/kg/day, with an arithmetic mean of 0.65 ± 1.43 µg/kg/day (this average includes seven of the 15 workers that had exposures of zero because the exposure contribution from the application could not be distinguished from the high baseline chlorpyrifos exposure based on pre-study urinary 3,5,6-TCP concentrations). The geometric mean dose for workers who had exposure above baseline levels (n=8) is 0.4 µg/kg/day. In accordance with HED policy, the geometric mean is used to assess exposures because the biomonitoring data are lognormally distributed. The mean values are in somewhat good agreement with the estimates from dosimetry. The biomonitoring arithmetic average for the eight workers who had exposures above baseline was 1.23 µg/kg/day (i.e., excludes the seven workers with no exposure from lawn treatment). The registrant speculated that the highest exposure of 4.84 µg/kg (for OH05) was from a secondary source because 67% of the 3,5,6-TCP was excreted on day 5 post exposure. However, this value was included in the average dose because each volunteer was instructed to avoid chlorpyrifos for 10 days prior and 5 days following the study.

Pre-exposure baseline chlorpyrifos doses ranged from 0.2 to 3.73 µg/kg with a mean of 1.54 µg/kg, despite the fact that workers were instructed to avoid chlorpyrifos exposure 10 days prior to the study initiation. The high baseline chlorpyrifos dose makes it difficult to interpret the biomonitoring results. For example, seven of the fifteen workers had exposure levels (based on urinary 3,5,6-TCP) less than baseline levels, and therefore, their exposure from broadcast turf application is probably within the seven worker-specific baseline range (0.94 to 3.73 µg/kg), and not zero as concluded by the registrant.

The analysis of blood samples drawn from each applicator 24 and 48 hours post exposure indicated that no significant depression in plasma and red blood cell cholinesterase activity, relative to pre-study activity levels, occurred to the applicators after the application of the Dursban Pro insecticide. All of the plasma and red blood cell cholinesterase activities were within the reference range for the laboratory of 1,000 to 3,500 and 5,300 to 10,000 international units (IU)/ liter (L), respectively except for the plasma pre-exposure level for volunteer OH15 (352 IU/L). It should be noted, however, that in animals peak cholinesterase inhibition occurs 3-6 hours post exposure. In addition, the prior exposure of many of these PCOs may have resulted in suppressed baseline cholinesterase levels.

The lower leg (calves) coverall samples contained approximately 80% of the total coverall chlorpyrifos, despite that only 9% of the dermal dose was attributed to the sock dosimeters. However, it should be noted that each worker wore knee high chemical resistant footwear during application (only chemical resistant footware is required by the label, not knee high footwear). In addition, the exposure from hand washes represented 11% of the total dermal exposure, despite the fact that each worker wore chemically-resistant gloves.

The majority of the exposure data meet the criteria specified in Series 875 Group A. The applications of 1 lb ai/acre used in this study represented 25% of the maximum rate for treatment of subsurface feeding insects of 4 lb ai/acre. For example, the study applied 2 gallons diluted spray/1000 ft^2 or a nominal rate of 1 lb ai/acre , while the label allows up to 4 lb ai/acre [2 lb ai/gallon at 2 gallon/acre (8 qts product/acre) for white grubs]. Therefore, it is possible that this study underestimates the actual exposures to LCOs that apply the maximum label rate for subsurface soil broadcast treatment. For comparison purposes, dose estimates were also calculated based on the maximum label rate of 4 lb ai/acre, as shown on Table 2. The label maximum adjusted dose estimates are four times higher than the estimated biomonitoring exposures, with a geometric mean of 1.6 μg/kg/day assuming there is a direct correlation between application rate and exposure.

In addition, TruGreen/ChemLawn (1999) data for 193 workers indicate that the actual spray time LCOs is 2.75 hours with a total work shift work time of 8.48 hours, in contrast to the 1.5 hour spray time and 6 hour work day evaluated in this biomonitoring study. Consequently, the LCO exposure estimates are likely to be underestimated, based on real life work conditions.

LCO Mixer/Loader Exposures

Because the biomonitoring study did not evaluate exposures for mixer and loading activities, these scenarios were evaluated using PHED V1.1. Two unit exposures for a mixer/loader handling liquid were evaluated and are presented in Table 2. One for a single layer of clothing and gloves, and the second for two layers of clothing and gloves. There is high confidence in the data quality for the dermal and inhalation unit exposure estimates from PHED.

Residential Application

HED has no data monitoring chlorpyrifos exposures to residents during broadcast or spot treatment of turf. Therefore, exposures were evaluated based on data obtained from the Residential SOPs (also from PHED V1.1) for mixing/loading and application activities. This assessment evaluates both the broadcast and spot treatment of turf, which are assumed to be short-term scenarios for residents. For the broadcast treatment, it was assumed that a resident would use a hose end sprayer to treat 0.5 acre/day of turf, which represents the mean to upper-percentile range of the distribution of lawn size, with Dursban 1-12 Insecticide (EPA Reg No. 62719-56; 12.6% ai; 1 lb ai/gallon). For spot treatment of turf, it was assumed that a resident would use a low pressure handwand to treat 1000 ft^2 with the same chlorpryifos product. Recent lawn size survey data suggest that 0.5 acre lawn size represents 73% of 2300 respondents, while nearly 16% of the respondents had lawn sizes that ranged from 0.57 to 1 acre (Outdoor Residential Use and Usage Survey and National Gardening Association Survey 1999). It is possible that this survey included residents that do not have yards (i.e., condominium, apartments, urban dwellings, etc). The dose estimates for residential use assume that individuals wear short pants, short sleeves and no gloves. For the hose-end sprayer, there is low confidence in dermal and inhalation unit exposure estimates, which are based on 8 dermal and inhalation replicates of C grade data, and 8 grade E hand replicates. For the low pressure handwand (liquid/open pour), there is low confidence in dermal unit exposure estimates, which are based on 9-80 dermal replicates of ABC grade data, and 70 hand replicates of all grades. There is medium confidence in the inhalation unit exposure estimates, which are based on 80 inhalation replicates of ABC grade data. The label recommends diluting 3-12 oz of Dursban 1-12 Insecticide (12.6% ai; 1 lb ai/gallon) with 1 to 3 gallons of water. As shown on Table 2, a range of dose estimates were calculated for broadcast treatment, assuming application of 22 gallons of diluted product (i.e., 1 gallon/1000 ft^2 or 22 gallons per 0.5 acre) at both the minimum and maximum dilution rates of 3 to12 oz/gallon/ water/ 1000 ft^2. The short-term dermal doses (not adjusted for absorption) range from 214 to 857 μg/kg, while the inhalation exposures range from 0.07 to 0.27 μg/kg/day. For spot treatment, it was assumed a resident could apply 1 gallon diluted product at the maximum application rate of 12 oz ai/gallon water 1000 ft^2, which resulted in short-term dermal and inhalation doses of 134 and 0.04 μg/kg/day, respectively. In addition, application of 1 gallon at the minimum application rate of 3 oz ai/gallon water 1000 ft^2 resulted in short-term dermal and inhalation doses of 34 and 0.01 μg/kg/day, respectively. These short-term dermal and inhalation dose estimates are presented on Table 2.

(3) Golf Course Use

Chlorpyrifos is applied to golf course turf. No chemical-specific data were submitted by DAS to assess the application of chlorpyrifos to golf courses by workers. According to the National Golf Course Superintendents Association (personal communication with Mark Hartman, SRRD) the wettable powder formulation is by far the most used formulation and that granular are not used often, if at all. The Association has mailed out a survey to their membership on use patterns (size of treated areas, number of applications, etc.) which they expect to complete shortly. In the interim, an assessment is provided for both the 1 and 4 lb ai/acre rates for both the liquids and wettable powders. Exposures were assessed for workers that mix/load and apply chlorpyrifos to golf course turf. Exposures were based on PHED VI.1 data, and were assumed to be short-term (i.e., less than 30 days) for contact with chlorpyrifos residues the day of treatment. The dose estimates are presented on Table 2. The following assumptions were used in this assessment:

- Application rates: Dursban Turf Insecticide (EPA Reg. No. 62719-35) turf rates range from 1 lb ai/acre for ants, cutworms, sod webworm, etc. to 4 lb ai/acre for white grubs (specific directions to water in using ½ to 1 inch of water) and bluegrass billbugs.

- Broadcast application of chlorpyrifos to non tee and green areas is assumed to be applied using groundboom equipment. Applications to greens and tees are assumed to be applied by handheld equipment.

In addition to the PHED data, HED also evaluated chlorpyrifos exposures during groundboom application based on biomonitoring data obtained from MRID 42974501. This study assessed workers in an open cab, wearing coveralls over a T-shirt, and no gloves. These results are also presented on Table 2.

(4) Application of a Ready-To-Use Formulated Product (MRID No. 44739301)

Exposure estimates were derived from a chemical-specific registrant-submitted study in which 15 homeowners were monitored during the outdoor application of a ready-to-use formulated product, Ortho Ant Stop containing approximately 0.5% chlorpyrifos. HED evaluated this study in DP Barcode D252738 (Memorandum from D. Smegal to M. Hartman, April 29, 1999). In this study, homeowners applied up to five 24 oz. ready-to-use disposable bottles (with screw on tops) over a one hour duration to the outside foundation and perimeter of the house, and other areas (e.g., flower beds) where ants were present. A total of fifteen adult volunteers (nine females and six males) in the area of Indianapolis, Indiana were evaluated. The volunteers wore standard clothing that consisted of a short-sleeve coveralls with long pants, underwear, and a baseball style hat, but no gloves. Volunteers wore their own uncontaminated shoes. Each volunteer was instructed not to treat their homes or yards with chlorpyrifos containing products either immediately before, during or after the conduct of the study, and to avoid chlorpyrifos-containing products 10 days prior and 4 days after application. The amount of active ingredient (ai) handled per replicate ranged from 0.015 g to 0.038 g (mean = 0.033 g; S.D. = 0.006 g).
Exposures were estimated based on both dosimetry measurements and biomonitoring of urinary 3,5,6-TCP. Dermal exposure was quantified using passive dosimetry [cotton underwear (T-shirt, briefs or women's underwear), short-sleeve cotton coveralls with long pant legs, and hand washes; and a baseball style hat]. Inhalation exposure was measured using a personal air pump attached to the test subject's belt. The pump was connected by tygon tubing with a 37-mm mixed cellulose ester filter (0.8-µm pore size) connected to a Chromosorb 102 vapor collection tube to evaluate inhalation exposures in the breathing zone of volunteers.

The total absorbed dose estimated from passive dosimetry range from 0.03 to 0.86 µg/kg/day, with a mean of 0.25±0.25 µg/kg/day. Approximately 12 percent of the absorbed dose, as estimated from the passive dosimetry data, resulted from inhalation (mean 0.03 µg/kg/day) and 88 percent from dermal exposure (0.23 µg/kg/day). The total absorbed dose estimated from biomonitoring ranged from 0 to 1.9 µg/kg/day, with an arithmetic mean of 0.49 ± 0.59 µg/kg/day, and a geometric mean of 0.24 µg/kg/day. The mean values are in somewhat good agreement with the estimates from dosimetry. The biomonitoring results are slightly higher, but given that hand wash residues contribute on average 57% of the total dermal exposure, it is possible that the volunteers may have incidentally ingested chlorpyrifos as well (which would only be captured in the biomonitoring results). Baseline chlorpyrifos pre-exposure ranged from 0.05 to 0.3 µg/kg with a mean of 0.12 µg/kg, despite the fact that volunteers were instructed to avoid chlorpyrifos exposure 10 days prior to the study initiation.

The geometric mean biomonitoring dose estimate of 0.24 µg/kg/day is used in this risk assessment in accordance with HED policy for lognormally distributed data sets. This dose was directly used to assess risk based on a comparison with the dermal absorbed NOAEL of 150 µg/kg/day from the 21 day dermal rat study (5000 µg/kg/day * 0.03 dermal absorption factor), because most of the exposure is via the dermal route. This dose estimate was divided into dermal and inhalation doses based on the passive dosimetry results, (i.e., 88% dermal and 12% inhalation), because there are different short-term inhalation and dermal endpoints for risk assessment. The resulting absorbed dose estimates used in the risk assessment are 0.029 µg/kg/day for inhalation and 0.21 µg/kg/day for dermal, as shown on Table 2. For short-term scenarios (such as residents), the absorbed dermal dose estimate from the biomonitoring results (absorbed dose) was further adjusted to an estimated dermal non-absorbed dose of 7 µg/kg/day (using a 3% dermal absorption factor) for direct comparison with the short-term dermal toxicity endpoint. These dose estimates represent a central-tendency to high-end scenario for residential applicators, who are more likely to apply one bottle of product rather than the five bottles used in the study, but could wear shorts rather than long pants. Chlorpyrifos residues on pants were on average 70% of the total dermal exposure.

This study met most of the requirements contained in the Series 875 Group A, Applicator Exposure Monitoring Test Guidelines, and the data are useful for risk assessment.

(5) Insecticidal Dust Product Application (Bulbous Duster or Shaker Can)

HED has no data monitoring exposures from chlorpyrifos application using a duster. Therefore, chlorpyrifos exposures were evaluated using a study in the scientific literature in which a dust formulation was applied to a home garden (Kurtz and Bode 1985). This analysis is presented in a memo from D. Jaquith to Chlorpyrifos file, June 11, 1996 entitled Documentation of Applicator Exposure Assessment for Chlorpyrifos Reregistration Eligibility Document--Application in the Residential Environment. Although chlorpyrifos dust products are not registered for garden use, this study is considered to represent the best surrogate data available because it measures exposure per quantity of product handled. For this assessment, both a residential applicator and utility workers (i.e., during application of product to underground wires or cables) were evaluated. It was assumed that a homeowner could dispense a 10 oz can of a 1% ai product (2.83 g ai) (EPA 62719-54) to treat a heavily infested home, while it was assumed a worker could handle a more concentrated product (Rainbow Ko Fire Ant Killer, 7% ai, EPA Reg 13283-17), which is sold in both 4 oz and 100 oz containers (7.9 and 198.4 g ai, respectively). The label notes that the 4 oz container treats 1 sq ft^2, while the 100 oz container treats up to 100 ft^2. It was assumed that a residential applicator would be exposed short-term (i.e., 1-30 days), and that a worker could be exposed both short- and intermediate-term (i.e., 30 days to several months).

In the study, 24, 15-minute replicates were available for individuals that dispensed 190 to 220 g of a 5 percent carbaryl dust product (9.5-11 g ai or 0.021-0.024 lb ai) using a shaker can to corn and beans. Measurements were taken of the total deposition of the material on the skin/clothing surfaces. The product was applied for 15 minutes, enough time to treat an average home garden or a heavily infested home. The total potential dermal exposure, measured using total deposition was 11 mg per 15 minute treatment (5.0×10^3 mg/lb ai). Respiratory exposure was not measured.

There are no data adequate to determine the amount of protection that clothing offers to dust formulations. Therefore, HED assumed that areas covered by clothing offer 50 percent protection and that gloves offer 90 percent protection. HED estimated exposure for workers based on total deposition, wearing long pants, long sleeves, and gloves to be 4.5 mg per 15 minutes (or 4.5 mg/10 g ai carbaryl) and total deposition for residents wearing long pants, short sleeves with no gloves to be 4.9 mg per 15 minutes (or 4.9 mg/10 g ai carbaryl). These data were normalized to g ai chlorpyrifos handled to assess an in home dust treatment. Therefore, residential chlorpyrifos exposure was estimated to be 1.4 mg ai (i.e., 4.9 mg/10 g ai carbaryl * 2.83 g ai chlorpyrifos), while worker exposure was estimated to range from 3.6 to 89 mg ai chlorpyrifos for a 4 oz and 100 oz container, respectively (i.e., 4.5 mg/10 g ai carbaryl * 7.91 or 198.4 g ai chlorpyrifos). As shown on Table 2, the resulting short-term dermal dose for residents is 20 μg/kg/day, while the short- and intermediate- term dermal doses to workers range from 51 to 1275 μg/kg/day. These exposure estimates are considered to be conservative because the quantity of chlorpyrifos dust used indoors by residents is likely to be much less than the quantity of dust products typically used in gardens.

(6) Granular Formulation Application by Hand

HED has no data monitoring exposures from chlorpyrifos application of granular formulation by hand (EPA Reg. 62715-14, 62715-210). Therefore, exposures were evaluated based on data obtained from PHED V1.1. for LCOs, and the Residential SOPs for residential applicators (also from PHED V1.1). The unit exposure estimates for LCOs assume workers wear chemical-resistant gloves plus long-sleeve shirt and long pants. There is medium confidence in the dermal and inhalation unit exposure estimates, which are based on 16 dermal, 15 hand, and 16 inhalation replicates of ABC grade data. It should be noted that the PHED unit exposure estimates are based on a single study in which a test subject wearing chemical-resistant gloves spread the granular formulation around the outside of the residence and over 90 percent of the samples contained no detectable material. Therefore, the exposure estimate is driven by the limit of detection of the analytical method. Because of the non-detection issue, HED also evaluated a resident wearing long pants, long sleeved shirt and gloves. In addition, dose estimates were calculated assuming LCOs wear a double layer of clothing. The dose estimates for residential use assume that individuals wear short pants, short sleeves and no gloves. In addition, residents that wear long pants, long sleeves and gloves were also evaluated due to the large number of non-detectable residues in the study. There is also medium confidence in the unit exposure estimates for residential exposure, which are based on 16 dermal, hand and inhalation replicates each of ABC grade data. It was assumed that an average application dispensed is 0.0459 lbs of active ingredient, which assumes a LCO or resident treats 1000 ft^2 of turf with an active granular formulation at 2 lb ai/acre. A preliminary review of a recent registrant-submission suggests that this rate is the typical, median rate used by the LCO industry to treat subsurface soil feeding insects (Jefferson Davis Associates, Inc. 1999). It was assumed that a LCO could apply a granular formulation for durations greater than 30 days and up to several months (i.e., intermediate term), while a resident is more likely to apply a granular formulation once or twice a season (i.e., short-term). Data submitted by TruGreen/ChemLawn (1999) shows that LCOs apply chlorpyrifos-containing insecticides April through October (approximately 6 months).

(7) Loading Granular Formulation and Applying with Belly-Grinder Equipment

HED has no data monitoring exposures from chlorpyrifos application of granular formulation using a belly-grinder. Therefore, exposures were evaluated based on data obtained from PHED V1.1. for LCOs, and the Residential SOPs for residential applicators (also from PHED V1.1). The unit exposure estimates for LCOs assume workers wear chemical-resistant gloves plus long-sleeve shirt and long pants. There is low confidence in the dermal unit exposure estimates, which are based on 29 to 45 dermal replicates of ABC grade, and 20 hand replicates of all grades of data. There is high confidence in the inhalation unit exposure estimates which are based on 40 replicates of AB grade data. In addition, dose estimates were calculated assuming LCOs wear a double layer of clothing. The unit exposure estimates for residential use assume that individuals wear short pants, short sleeves and no gloves. There is also medium confidence in the dermal unit exposure estimates for residential exposure, which are based on 20 to 45 dermal, and 23 hand replicates each of ABC grade data. There is high confidence in the inhalation unit exposures, which are based on 40 replicates of AB grade data. Similar to the scenario discussed above, it was assumed that an average application dispensed is 0.97 lbs of active ingredient based on a DAS-submitted study of a granular formulated product (MRID 44167101). This assumption is based on a LCO or resident that treats 0.5 acre of turf with an active granular formulation at 2 lb ai/acre. Recent lawn size survey data suggest that 0.5 acre lawn size represents 73% of 2300 respondents., while nearly 16% of the respondents had lawn sizes that ranged from 0.57 to 1 acre (Outdoor Residential Use and Usage Survey and National Gardening Association Survey 1999). It is possible that this survey included residents that do not have yards (i.e., condominium, apartments, urban dwellings, etc). A preliminary review of a recent registrant-submission suggests that this rate is the typical, median rate used by the LCO industry to treat subsurface soil feeding insects (Jefferson Davis Associates, Inc. 1999). HED also evaluated a spot treatment scenario of 0.0459 lb ai per 1000 ft^2. It was assumed that a LCO could apply a granular formulation for durations greater than 30 days up to several months (i.e., intermediate term), while a resident is more likely to apply a granular formulation once or twice a season (i.e., short-term). Data submitted by TruGreen/ChemLawn (1999) shows that LCOs apply chlorpyrifos-containing insecticides April through October (approximately 6 months).

(8) Loading Granular Formulation and Applying with a Push-Type Spreader

HED has no data monitoring exposures from chlorpyrifos application of granular formulation using a push-type spreader. Therefore, exposures were evaluated based on data obtained from PHED V1.1. for LCOs, and the Residential SOPs for residential applicators (also from PHED V1.1). The unit exposure estimates for LCOs assume workers wear chemical-resistant gloves plus long-sleeve shirt and long pants, while residents are assumed to wear short pants, short sleeves and no gloves. There is low confidence in the dermal unit exposure estimates for LCOs and residential applicators due to inadequate replicate numbers, which are based on 0 to 15 dermal replicates of C grade data, 0 hand replicates for LCOs and 15 hand replicates each of C grade data for residents. There are no head, neck or hand replicates for the LCO clothing scenario. In addition, dose estimates were calculated assuming LCOs wear a double layer of clothing. For residents, a 50 percent protection factor was used to back calculate a short-sleeved scenario from the long sleeved data. There is high confidence in the inhalation unit exposure estimates for both LCOs and residents, which are based on 15 replicates of B grade data. Similar to scenario discussed above, it was assumed that an average application dispensed is 0.97 lbs of active ingredient based on a DAS-submitted study of a granular formulated product (MRID 44167101). As noted above, this assumption is based on a LCO or resident that treats 0.5 acre of turf with an active granular formulation at 2 lb ai/acre. Recent lawn size survey data suggest that 0.5 acre lawn size represents 73% of 2300 respondents., while nearly 16% of the respondents had lawn sizes that ranged from 0.57 to 1 acre (Outdoor Residential Use and Usage Survey and National Gardening Association Survey 1999). It is possible that this survey included residents that do not have yards (i.e., condominium, apartments, urban dwellings, etc). A preliminary review of a recent registrant-submission suggests that this rate is the typical, median rate used by the LCO industry to treat subsurface soil feeding insects (Jefferson Davis Associates, Inc. 1999). It was assumed that a LCO could apply a granular formulation for durations greater than 30 days up to several months (i.e., intermediate term), while a resident is more likely to apply a granular formulation once or twice a season (i.e., short-term). Data submitted by TruGreen/ChemLawn (1999) shows that LCOs apply chlorpyrifos-containing insecticides April through October (approximately 6 months).

(9) Pre-Construction Termiticide Use for Subterranean Termite Control (Mixing/Loading and Applying) (MRID No. 44589001)

Exposure estimates were derived from a chemical-specific study submitted by Dow AgroSciences in which workers were monitored during application of chlorpyrifos, as the termiticide Dursban® TC (43.2% ai) (EPA Reg. 62719-47), during pre-construction termiticide treatments. HED evaluated this study in DP Barcode D247635 (Memorandum from J. Cruz to M. Hartman, May 24, 1999). This study quantified exposures to a mixer/loader/applicator (M/L/A) during mixing/loading/application and tarp pulling processes.

The M/L/A performed an open-pour mixing/loading task in which a PCO loaded Dursban® TC concentrate into a mixing tank containing the appropriate amount of water. After mixing, the diluted product was sprayed onto the soil using a hand-held sprayer and then two workers (tarp pullers) laid the untreated plastic tarp over the treated soil prior to pouring the concrete foundation.

The product was diluted to a nominal rate of 1% (actual 1.44%) prior to application. All applications were made with a low pressure spray equipment fitted with a hand-held hose-end sprayer or spray wand fitted with a shrouded rose nozzle. The flow rates at which the spray was applied to the sites varied depending on the truck, but in general applications were between 8 to 12 gallons/minute. There were 17 M/L/A replicates, representing at least three hours exposure time per replicate. There were16 tarp puller replicates each representing 6-7 minutes. Each worker completed 8 tarp pulling replicates in less than one hour. M/L/A wore long underwear, a long sleeved shirt, long pants, and PPE consisting of rubber boots, tyvek or cotton coveralls, and arm-length gloves (note the label only requires a single layer of clothes; the coveralls and arm-length gloves are not required). Each worker removed their PPE after the spray operation was concluded. The tarp pullers wore a long sleeved shirt, long pants socks, leather and/or rubber boots, and a hat. In addition, one half (8) of the workers wore arm-length chemical resistant gloves, while the other half (8) did not wear gloves.

Dermal exposure was quantified using whole body dosimeters, and hand washes. For M/L/A, each participant wore a whole body dosimeter consisting of a long sleeved shirt and pants which were segmented and analyzed to determine potential exposures for the arms, upper legs, lower legs and torso. In addition, an undergarment consisting of one-piece cotton long underwear was collected to determine the penetration of chlorpryifos through outer clothing onto skin. Note that M/L/A replicates also wore a Tyvek (9 replicates) or cotton (8 replicates) coverall on top of the whole body dosimeter as personal protective clothing. A hat with a denim patch was analyzed to quantify head, neck, and face surface deposition.

Air samples were collected using a personal air sampling pump connected to a 37-mm GN-4 filter in series with a Chromosorb 102 tube. The filters were used to collect particulates while sorbent tubes were used to trap vapors. Samples were analyzed using GC-ECD.

As shown on Table 2, the average dermal absorbed dose (assuming a 3% dermal absorption rate) for the M/L/A wearing a single layer of clothes is 1.57 μg/kg/day, while the average inhalation dose is 0.45 μg/kg/day, based on passive dosimetry. The average dermal absorbed dose for the M/L/A wearing a double layer of clothes is 0.477 μg/kg/day, while the average inhalation dose is 0.45 μg/kg/day, based on passive dosimetry. These exposure estimates are for a 3 hour exposure measured in the study.

As shown on Table 2, the average dermal absorbed dose for the tarp pullers contacting one tarp without gloves is 0.081 μg/kg/day, while the average inhalation dose is 0.015 μg/kg/day, based on the passive dosimetry measurements. In addition, it was assumed that a worker could pull 8 tarps in one work day, which the study evaluated for construction of townhouses, or other homes under construction in close proximity. Therefore, the average 7 minute exposure for each tarp was multiplied by a factor of 8. The average dermal absorbed dose for the tarp pullers contacting eight tarps without gloves is 0.644 μg/kg/day, while the average inhalation dose is 0.122 μg/kg/day. The average dermal absorbed dose for the tarp puller wearing arm-length chemical-resistant gloves and contacting one tarp is 0.023 μg/kg/day, while the average inhalation dose is 0.021 μg/kg/day based on passive dosimetry. The average dermal absorbed dose for the tarp puller wearing arm-length chemical-resistant gloves and laying eight tarps is 0.177 μg/kg/day, while the average inhalation dose is 0.168 μg/kg/day based on passive dosimetry. It was assumed that these workers could be exposed for more than several months a year (i.e., long term).

(10) Post Construction Termiticide Use (Mixing/Loading and Applying) for Subterranean Termite Control (MRID No. 44729402)

Exposure estimates were derived from a chemical-specific study submitted by Dow AgroSciences in which workers were monitored during application of chlorpyrifos, as the termiticide Dursban® TC (43.9% ai) (EPA Reg. 62719-47), during post-construction termiticide treatments. HED evaluated this study in DP Barcode D252357 (Memorandum from G. Bangs to M. Hartman and D. Smegal, April 29, 1999). This study quantified potential pesticide applicator inhalation, dermal, and biological exposure to chlorpyrifos. The mixing/loading and application were monitored as a combined job function. Post-construction treatments were applied to various construction styles of residential housing (i.e., slab-on-grade, basement, crawlspace and combinations thereof) in Virginia, Alabama, and Georgia. The applicators applied the termiticide at a rate of approximately 4 gallons of ~1 percent a.i. dilution (range 0.71-1.24%) per 10 linear feet using an average of 124 gallons per structure (range 40-325 gallons). Mixer/loader/applicator exposures during actual structural work using hand held spray gun or injection rod were monitored by passive dosimetry and limited biomonitoring of volunteer PCO. During applications, the PCOs wore the label-required protection, including a cotton coverall, chemically resistant nitrile gloves, a hat, protective eyewear and a half-facepiece respirator (if working in confined spaces). During mixing/loading, subjects wore additional PPE that consisted of chemically resistant footwear and an extra (second) coverall or a chemically resistant apron. There were a total of 15 replicates representing 9 different volunteers, from 3 companies in three cities. The study was conducted in compliance with most, but not all, OPPTS guidelines. The biomonitoring was very limited (5 replicates).

Higher inhalation exposures were encountered in basement and crawlspace applications than during slab treatments. The arithmetic mean inhalation dose is 1.48 μg/kg/day (normalized 70 kg body weight), and ranged from 0.17 to 3.18 μg/kg/day normalized body weight (N=14). The geometric mean dose is 0.91 μg/kg/day. The arithmetic mean value is based on data from 14 replicates because the fifteenth replicate had an unusually high dermal dose (50 μg/kg) resulting from an accident with a broken hose. Average inhalation exposure/hour (average 6.62 hours worked) was 15 μg/hr, with a range of 1.67 to 25.84 μg/hr.

During crawlspace treatments, workers experienced the greatest amount of dermal exposure to the head/neck (~48 percent of the dermal exposure on average). During slab and basement treatments, workers experienced the highest levels of dermal exposure to the legs (~63 percent and ~51 percent respectively on average). During basement treatments, exposure to the hands was greatest (~23 percent of total dermal exposure on average), however the number of application replicates was low (N=3). The arithmetic average dermal absorbed dose (N=14) based on passive dosimetry was 3.28 μg/kg/day with a range of 0.45 to 13.85 μg/kg/day, and excluding the 49.9 μg/kg/day dose due to one replicate being sprayed by a broken hose. The geometric mean absorbed dermal dose is 2.48 μg/kg/day, including the individual sprayed with a broken hose. These values utilize the current HED dermal absorption factor of three percent.

The total mean dose, calculated by addition of average inhalation and absorbed dermal doses, was estimated to be 4.76 μg/kg/day (normalized 70 kg body weight; N=14; range: 0.82 to 16.7 μg/kg/day), with inhalation representing 31 percent and dermal representing 69 percent of total dose measured via passive dosimetry. Total estimated dose (dermal and inhalation) for the 15th replicate was 50.50 μg/kg/day, which may be considered a worst-case exposure because it represents an equipment malfunction (i.e., broken hose).

Total mean absorbed chlorpyrifos dose of 4.27 μg/kg/day measured via the biological monitoring of the five workers in Georgia is slightly higher than the total absorbed chlorpyrifos dose calculated as the sum of 3 percent of total potential dermal dose (corrected for dermal absorption; measured via passive dosimetry) and potential inhalation dose for the same 5 replicates (3.24 μg/kg/day). Total absorbed dose was estimated directly by biomonitoring of the chlorpyrifos metabolite 3,5,6-TCP in the urine samples of five volunteer applicators at the Georgia location (it is unclear why the fifth replicate had the same weight as another, unless one volunteer was monitored for 2 days). The volunteers were told to avoid chlorpyrifos exposure for ten days before the exposure application and for five days after the exposure. Each applicator collected all the urine voided on the day before application, the day of application, and for four consecutive days after initial exposure. The urine was collected at 12-hour intervals. The first day's collection was used as the baseline for correcting exposure calculations. The baseline chlorpyrifos ranged from 0.39 to 3.4 μg/kg(actual body weight)/day, with a mean of 1.1 μg/kg/day. The difference in estimated absorbed dose levels between biomonitoring and passive dosimetry may be due to various factors, including: incidental oral exposure to chlorpyrifos; field spike recovery from coveralls was consistently low (mean = 22 % ± 13%), so losses may not have been fully accounted for, or; subjects participating in biological monitoring experienced exposure to chlorpyrifos outside the study setting. (Note: the dose estimates were corrected for the low field recovery).

In at least three cases (replicates AL03, GA13, GA14), significantly more ai was reportedly applied than was mixed, and the study report does not explain how that is possible (i.e., presumably the applicators used other, previously prepared solution in addition to their own). For example, the amounts mixed for replicates AL03, GA13 and GA14 were 12, 4 and 3 lb ai/day, respectively compared to the amounts applied which were 16.5, 5.1 and 5 lb ai/day, respectively. A range of unit doses based on passive dosimetry were estimated by applying the mean exposure (normalized to μg/lb ai) of the 14 replicates to the high (32.7 lb), low (4.0 lb), and mean (10.72 lb) amount of material handled.

These data in MRID 44729402 are comparable with a similar scenario in PHED V1.1. There are 17 surrogate replicates in PHED monitored as a combined job function of mixing/loading/applying a termiticide via rod injection. The dermal exposures were monitored under single layer clothing and chemical resistant gloves. The dermal unit exposure is 360 μg/lb ai, adjusting for a 3%

dermal absorption, the value is 11 μg/lb ai. The inhalation unit exposure was measured as 2.2 μg/lb ai (using the Subdivision U inhalation rate of 29 L/minute). Thus, the geometric mean biological monitoring unit exposure (D255669) of 16 μg/lb ai is consistent with the PHED best fit unit-exposure (dermal plus inhalation) of 13 μg/lb ai. The difference can be attributed to many variables (e.g., test subject hygiene, small sample sizes, variable dermal absorption rates based on amount deposited on skin, incidental oral ingestion, etc). However, there is close agreement.

(11) Paintbrush Application

HED has no data monitoring exposures to chlorpyrifos resulting from a paintbrush application to treat insect-infested wood. Therefore, exposures were evaluated based on data obtained from the Residential SOPs (12/18/97) for residential applicators (also from PHED V1.1). These data represent a worker painting a bathroom with a fungicide-treated latex paint. PCOs were not evaluated for this scenario because they are assumed to treat larger surfaces of wood with rollers or a spray, rather than a paintbrush. The unit exposure estimates for residential use assume that individuals wear short pants, short sleeves and no gloves. There is low to medium confidence in the dermal unit exposure estimates for residential exposure, which are based on 14 to 15 dermal replicates of grade C data, and 15 hand replicates of B grade data. There is medium confidence in the residential inhalation unit exposure estimates, which are based on 15 inhalation replicates of C grade data. HED conducted two evaluations, a high end scenario that assumed an individual could apply one gallon of diluted chlorpyrifos product (as Dursban 1-12 Insecticide; EPA Reg No. 62719-56) to treat a large wood-infested area, and a more typical scenario which assumed the application of a quart of diluted product for a localized wood infestation. The label recommends diluting 5.33 oz of Dursban 1-12 Insecticide (12.6% ai; 1 lb ai/gallon) with 1 gallon of water. The resulting short-term dermal (potential exposure, not absorbed) and inhalation dose estimates for the high end scenario are 140 and 0.17 μg/kg/day, respectively, while the typical scenario doses estimates are 34 and 0.043 μg/kg/day, respectively. The dose estimates are presented on Table 2.

(12) Ornamental Application

HED has no data monitoring chlorpyrifos exposures to residents during mixing/loading or application to ornamentals (flowers, shrubs, evergreens, vines, shade and flowering trees and other ornamental plants). Therefore, exposures were evaluated based on data obtained from the Residential SOPs (12/18/97) (also from PHED V1.1) for mixing/loading and application activities. This assessment evaluates application via both a low pressure handwand and a hose end sprayer, which are assumed to be short-term scenarios for residents. A range of exposure estimates were evaluated for both application methods, the minimum, typical and maximum dilution rates of 1 oz, 4 oz and 1 quart of product per 3 gallons of water. The maximum rate is recommended for beetles. It was assumed that a resident would apply 5 gallons of diluted Dursban 1-12 Insecticide (EPA Reg No. 62719-56; 12.6% ai; 1 lb ai/gallon), in accordance with the residential SOPs for treatment of ornamental trees. The unit exposure estimates for residential use assume that individuals wear short pants, short sleeves and no gloves. For the hose-end sprayer, there is low confidence in dermal and inhalation unit exposure estimates, which are based on 8 dermal and inhalation replicates of C grade data, and 8 grade E hand replicates. For the low pressure handwand (liquid/open pour), there is low confidence in dermal unit exposure estimates, which are based on 9-80 dermal replicates of ABC grade data, and 70 hand replicates of all grades. There is medium confidence in the inhalation unit exposure estimates, which are based on 80 inhalation replicates of ABC grade data. As shown on Table 2, the dermal dose estimates range from 5.6 to 594 μg/kg/day, while the inhalation dose estimates range from 0.0018 to 0.18 μg/kg/day. The use of the low pressure handwand results in higher exposures.

Table 2 presents the exposure scenarios and exposure calculations using the above data sources for the residential uses of chlorpyrifos. Children are not included in this table since children would not be expected to apply this material, although they might be exposed after application.

(13) Mosquitocide Mixer/Loader/Applicator

HED has no data monitoring exposures to workers resulting from mixing/loading or applying chlorpyrifos-containing mosquitocide products. Therefore, exposures were evaluated based on agricultural data obtained from PHED V1.1. The PPE unit exposure estimates for handlers assume workers wear chemical-resistant gloves plus long-sleeve shirt and long pants (i.e., single layer clothing), except for aerial mixer/loader, where a double layer of clothing was assumed. Aerial and ground-based fogger applicators were not assumed to wear gloves. In addition, exposures were estimated for the use of engineering controls (i.e, closed systems for mixing, and enclosed cabs/cockpits). Only one application rate was assessed for aerial application (i.e., 0.023 lb ai/acre), while two application rates were assessed for ground-based fogger (i.e., 0.005 and 0.01 lb ai/acre) based on Mosquitomist One U.L.V label directions. Both short- and intermediate term exposure durations were assessed due to the absence of frequency data. This should be considered a range-finder assessment because agricultural exposure data were extrapolated for mosquitocide uses. Uncertainties arise from: (1) extrapolation of agricultural exposure data for similar uses related to mosquitocide uses (i.e,. mixer/loader and application of liquid products), (2) the large number of acres treated (i.e., 7500 acres for aerial and 3000 acres for ground-based fogger application), (3) frequency of use and exposure to workers, and (4) surrogate ground-based fogger exposure data are not available, and therefore, it was necessary to extrapolate from airblast exposure data.

3.2 <u>Residential/Worker Postapplication Exposures & Assumptions</u>

This section is organized into three main sections: (1) Indoor postapplication exposures; (2) Outdoor postapplication exposures; and (3) Scientific Literature Discussion.

EPA has determined that there is potential exposure to the general public (adults and children) following applications at residential and public sites - indoors and outdoors. Postapplication exposure data were required for chlorpyrifos in a reregistration DCI issued September 19, 1991 during the reregistration process, since, at that time, one or more toxicological criteria had been triggered for chlorpyrifos. The dose estimates are presented in Tables 3 and 4.

The following studies were submitted by the registrant:

- MRID No. 40094001 Airborne Chlorpyrifos Concentrations Measured During and Following Applications of Dursban TC Insecticide to Residential Dwellings. GH-P 1310.

- MRID No. 430135-01 Vaccaro et al. 1993. Chlorpyrifos: Exposure to Adults and Children Upon Reentry to Domestic Lawns, Following Treatment with a

Chlorpyrifos-Based Mixture. Study ID No. DECO-HEH2.1-1-182(121).

- MRID No. 441671-01 Vaccaro et al. 1996. Chlorpyrifos: Exposure to Adults and Children Upon Reentry to Domestic Lawns, Following Treatment with a Chlorpyrifos-Based Granular Insecticide.

- MRID No. 444582-01 Byrne et al. 1998. Residential Exposure to Chlorpyrifos from Reentry to Structures Treated with Crack and Crevice and Spot Applications of Dursban Pro.

HED reviewed each of these studies and used the registrant-submitted data to estimate exposures to adults and children in residential settings. A brief summary of each study is provided below, with reference to HED's memorandum that provides a more detailed review and analysis of the study. As noted previously, a number of the registrant-submitted studies conducted biomonitoring by measuring urinary concentrations of the primary chlorpyrifos metabolite 3,5,6-trichloro-2-pyridinol (3,5,6-TCP), to estimate chlorpyrifos exposures. Prior to the studies, baseline urinary 3,5,6-TCP concentrations were determined in the study volunteers, and these baseline measurements were subtracted from the exposure-related 3,5,6-TCP concentrations measured in the biomonitoring study. It is important to note that most individuals in the U.S., and nearly all the subjects in the Dow AgroSciences biomonitoring studies had low levels of urinary 3,5,6-TCP prior to study commencement, indicating a baseline exposure to chlorpyrifos, chlorpyrifos-methyl and/or 3,5,6-TCP as a result of dietary and/or residential/commercial/institutional exposures (Hill et al. 1995).

3.2.1 INDOOR POSTAPPLICATION EXPOSURES.

(1) Crack, Crevice and Spot Treatment of Kitchen and Bathroom (MRID 44458201) (Inhalation Exposures in a Treated Room)

Dow AgroSciences submitted a study designed to estimate chlorpyrifos exposure to adults conducting normal daily activities following treatment of the kitchen and bathroom of three houses with crack and crevice and spot applications of Dursban Pro insecticide (0.5% chlorpyrifos dilution with water) for cockroach control. HED evaluated this study in DP Barcode D242444 (Memorandum from D. Smegal to M. Hartman, December 3, 1998). Between 0.663 and 0.787 L of product (3.32 g to 3.94 g chlorpyrifos) was applied to the houses. Six adults (four women and two men), two from each of the three treated houses, were monitored 1 day pre-application and for 10 days postapplication via urine collection and analysis. The urine was analyzed for 3,5,6-TCP, the primary metabolite of chlorpyrifos. The volunteers were instructed to perform normal activities and to spend at least 12 hours per day inside the treated house. Air monitoring was conducted at two heights in the kitchen (site of application) and family room (adjacent room). In addition, deposition measurements and dislodgeable residues were collected in the family room and a bedroom of each treated house. Dislodgeable residues were measured on hard plastic toys (balls), and also on carpets in the family room and bedroom, to determine the amount of chlorpyrifos available for absorption.

Dislodgeable residues from the carpet and hard toy wipes in non-treated rooms were generally non detectable, indicating that the potential for dermal absorption is low. Based on the biomonitoring and environmental data collected in this study, the maximum one-day chlorpyrifos dose for the 6 adult volunteers, corrected for baseline exposure, is 0.39 μg/kg/day which is comparable to or less than estimated chlorpyrifos baseline doses of 0.1 - 0.86 μg/kg/day. The overall mean dose to the six volunteers is 0.18 μg/kg/day based on the biomonitoring data, while the mean baseline dose is 0.4 μg/kg/day. The method used to estimate exposures directly measures internal dose and does not differentiate between routes of exposure. However, the study results indicate that the predominant route of exposure is through inhalation.

Exposures to young children were estimated using air concentrations measured 15 inches above the floor, and standard EPA default exposure assumptions (i.e., breathing rate, body weight and duration of exposure). Dermal and oral exposures were assumed to be negligible based on an absence of detectable dislodgeable residues in the carpet wipes or on hard plastic toy wipes in all three houses (in untreated rooms), except for a negligible quantity of residue detected on a hard ball in the family room of house #3. For example, if a child ingested the entire residue present on the toy, the resulting dose would be approximately 0.089 μg or 0.006 μg/kg, which is negligible relative to the estimated exposures from inhalation (10 -100 fold less). The estimated 10 day mean doses to children are 0.08, 0.28 and 0.22 μg/kg/day, while the highest one-day doses are 0.27, 0.76 and 0.61 μg/kg/day for houses #1, #2 and #3, respectively. These exposure estimates are also within the background range observed for adults. The one day exposure estimates are conservative, because they assume a child could spend 21 hours exclusively in a treated room. The 21 hours/day estimate represents the 50th percentile for time spent at home for children ages 1-4 years old according to USEPA Exposure Factor Handbook (1997). However, this study did not evaluate chlorpyrifos residues on soft plush toys, which could also contribute to child exposure. In addition, the study did not adequately evaluate potential chlorpyrifos residues on the floor or other surfaces in treated rooms as no dislodgeable residues were collected in the kitchen or bathroom (only in adjacent, untreated rooms). A few deposition measurements were collected in the kitchen and bathroom (total of seven from all three houses) from 0-2 hours post treatment. However, these data are inadequate for risk assessment because of the small number of measurements (from 3 houses), and because deposition measurements increased over time in untreated rooms (up to 10 days), therefore, the 0-2 hour levels are unlikely to reflect potential longer-term exposures. For example, it should be noted that the highest deposition in an adjacent untreated room(2.298 μg/100 cm^2) was higher than 5 of the 7 treated room 0-2 hour deposition measurements.

In conclusion, these data demonstrate that exposures to adults following crack, crevice and spot applications of chlorpyrifos in the kitchen and bathroom by a licensed applicator are comparable to typical background exposures levels based on biomonitoring data where adults were in the house 12 hours per day. The adult biomonitoring data are insufficient to characterize child exposures due to the vastly different activity patterns of adults and children (i.e., children crawl, have more hand to mouth activity, and typically spend more time at home, etc). These data do not support the use of crack and crevice or spot treatment in bedrooms, living rooms, closets, day care centers, schools, playhouses, on furniture or draperies, or in other rooms that could result in higher exposure to individuals, particularly children. In addition, these data do not support the indoor application of up to 1% Dursban Pro for the treatment of exposed wood surfaces, voids and channels in damaged wood, wall voids, and junctions between wood and foundation that are currently listed on the label.

In addition, low air concentrations of chlorpyrifos were still present in all three homes 10 days post treatment, however some of the current labels allow re-treatment every 7 days. In one house, the highest daily average air concentrations were detected on the 6th day following chlorpyrifos treatment, indicating possible sinks and resuspension. The results of this assessment are presented in Table 3. This study has not addressed the possible cumulative effects of multiple treatments over time, although, additional information was requested from the registrant to support a 7 day re-treatment interval as proposed in the Dow AgroSciences submission (MRID 44331901). DAS submitted additional analysis of the same air measurements to demonstrate that the potential for cumulative effects was minimal. HED however, believes additional data are necessary to alleviate our concerns pertaining to frequent indoor re-treatments. HED requests treated room residue data for floors, furniture and other surfaces available for contact by children for both chlorpyrifos, and its primary degradation metabolite, 3,5,6-TCP following multiple treatments, in addition, to chlorpyrifos air measurements in treated rooms following multiple treatments (i.e., at a minimum 3 treatments 7 days apart). Residue data for 3,5,6-TCP are important due to the potential for accumulation and persistence of this environmental degradate.

(2) Crack and Crevice Treatment of Other Rooms Using Residential SOPs (Dermal and Oral Exposures in an Untreated Room)

HED also assessed potential short-term exposures to adults and children using the updated Residential SOPs (2000), to supplement the evaluation of crack and crevice treatment based on the registrant-submitted biomonitoring study discussed above. This additional assessment was conducted due to the concerns that the registrant-submitted biomonitoring did not adequately evaluate exposures that could occur following treatment of baseboards and window and door frames in family rooms, bedrooms, living rooms or other treatments that could occur in schools, day care centers, playhouses, or the many other buildings listed on the labels.

The highest deposition residue detected in the untreated family room of house #3 (room adjacent to treated kitchen) from the registrant-submitted biomonitoring study was used in this analysis (i.e., 2.298 μg/100 cm^2 collected one day postapplication). This assumption was considered reasonable, although it would have been preferable to have actual residue data from the treated kitchen (these data were not provided). Exposures were estimated for both adults and children, assuming that 5% of the residue is available as dislodgeable residue. The standard default assumptions recommended in the Residential SOPs were used, which include: body weights of 70 and 15 kg for adults and children, respectively, transfer coefficients of 16,700 and 6,000 cm^2 for adults and children, respectively, exposure time of 8 hours for contact with carpet and 4 hours for contact with surfaces, child finger surface area of 20 cm^2, and a frequency of finger to mouth activity of 20 times/hour. For oral exposures, it was assumed that 50% of the chlorpyrifos residues are extracted in saliva. The transfer coefficients were based on Jazzercise data that showed a 20 minute exposure resulted in approximately 66,666 cm^2, which is equivalent to 16,700 cm^2 for adults over a 4 hour period. The child transfer coefficient was based on a scaling of toddler surface area to adult surface area which is approximately 2.9:1. Inhalation exposures were not calculated using the SOPs, because comprehensive air monitoring was conducted in the registrant-submitted biomonitoring study, and HED believes inhalation exposures were adequately characterized for treated rooms. The estimated doses for dermal and oral exposures are presented on Table 3. As shown on the table, the estimated doses are lower than those estimated from the biomonitoring study. However, the inhalation dose is from a treated room, whereas the SOP dermal and oral exposure estimates are based on untreated room deposition measurements.

Therefore, dermal and oral exposure are likely to be higher in a treated room. As noted above, HED has requested treated room residue data for floors, furniture and other surfaces available for contact by children for both chlorpyrifos, and its primary degradation metabolite, 3,5,6-TCP following multiple treatments. Residue data for 3,5,6-TCP are important due to the potential for accumulation and persistence of this environmental degradate.

Scientific Literature on Indoor Broadcast Application

In 1998, scientists at Rutgers University published a study that evaluated exposure to children following a single broadcast use of chlorpyrifos in two apartments by a licensed pesticide applicator (Gurunathan et al. 1998). The Gurunathan et al. (1998) study evaluates a broadcast application, a method which the registrant voluntarily canceled in 1997, that raises some exposure issues not fully addressed by a crack and crevice application study discussed above (MRID No. 44458201). For example, the broadcast study detected chlorpyrifos residues in plush toys placed in treated rooms one hour after application, whereas, the crack and crevice study only measured dislodgeable residues from carpets and hard plastic toys 1 hour to 10 days post-treatment that were placed in untreated rooms (i.e., bedroom and family room) prior to treatment. In addition, the broadcast study accounted for the frequent hand-to-mouth activity of children based on videotaping, which the crack and crevice study could not adequately address because it estimated adult exposures (whose activity patterns are different) based on biomonitoring data. Gurunathan et al. (1998) measured chlorpyrifos in air, plastic and plush toys, and in dust in and on smooth surfaces. This study estimated child doses of 208 μg/kg/day (or 634 μg/kg/day for high hand to mouth contact) based on environmental measurements and conservative exposure assumptions. However, these exposure estimates were not validated by actual measurements of absorbed doses based on urinary excretion of 3,5,6-TCP (as was done for the crack and crevice study discussed above). The study concluded that dermal and oral exposures via toys and other surfaces may present greater risk than inhalation, and that potential inhalation exposure was negligible. In addition, this study observed continued deposition on surfaces in treated rooms 2 weeks postapplication, and demonstrated that chlorpyrifos may adhere to objects brought into a room hours or days after pesticide application. Peak deposition on surfaces (of plastic toys) occurred 36 hours postapplication (0.043 $\mu g/cm^2$). The authors suggest that the current labels specifying a re-entry time for residents of 1-3 hours based on air measurements may be inadequate, and that routine application could lead to the accumulation in toys or other sorbant surfaces (i.e., pillows). The authors recommend that toys should not be stored in open rooms at least one week after broadcast application of chlorpyrifos.

HED evaluated this study, and concluded that it significantly overestimates the typical child doses resulting from currently registered indoor uses. In addition, the estimates in this study are significantly higher than those estimated based on a broadcast application biomonitoring study submitted by the registrant (MRID No. 42008401), and reviewed by HED (memo from D. Jaquith to D. Edwards, DP Barcode: D168824, August 18, 1995). For example, HED estimated child doses of 23 μg/kg/day on day one and 14 μg/kg/day on day two following a broadcast application. The following is a list of refinements that need to be considered, or uncertainties that exist in the Gurunathan et al. (1998) study:

- A total of 12 g of chlorpyrifos was applied directly to entire floor surfaces of each room, which is approximately three times more than the amount applied for crack and crevice treatment (3.32-3.94 g based on the study above).

- The toys (plush and plastic) were placed directly on treated surfaces 1 hour postapplication, which enhances the quantity of chlorpyrifos sorbed to the toys, relative to the amounts found from air deposition in the crack and crevice study. Current registered uses (i.e., crack and crevice) are not likely to result in toys contacting treated areas.
- A hexane-methanol solvent was applied to the dresser surfaces and was used in the wipe samples, while hexane was used to extract dust and toy residues. The solvent enhances chemical availability from the surfaces resulting in higher residue measurements than are likely to be absorbed by an individual contacting or handling these surfaces/toys.
- The bioavailability of chlorpyrifos in the toys (i.e., amount available for absorption) was not addressed, as noted by the study authors.
- The exposure estimates assumed that children touch a contaminated surface 366 times/hour and put their contaminated hand in their mouth 70 times/hour. However, it is unlikely that chlorpyrifos concentrations are replenished on the entire hand surface every time a child touches a surface.
- The hand surface area and inhalation rate used to estimate child exposures are higher than EPA's recommended values in the Draft Residential Exposure SOPs or the Exposure Factors Handbook (i.e., study used 400 cm^2 for hand surface area and 12 m^3/day for inhalation rate compared to the mean EPA-recommended values of 350 cm^2 and 8.3 m^3/day, respectively).

The Agency concludes that the screening-level estimate derived in this study can be better refined using values from the EPA's Exposure Factors Handbook, conducting biomonitoring to determine absorbed dose, and using more realistic sampling methodologies.

(3) Pet Collar Uses

A number of pet collars are currently registered. HED has no chemical-specific data that evaluate exposures to individuals from the use of pet flea collar products. Therefore, HED conducted this analysis in accordance with HED’s 1997 Draft SOPs for Residential Exposure Assessments. However, a pet collar exposure study is underway at Mississippi State University by Dr. Janice Chambers. Preliminary data from 12 dogs in this study demonstrate that dislodgeable residues are available directly from the collar, and also from contact with the fur from the neck and back areas in approximate ratios of 66:37:1 following very vigorous rubbing. Residues were fairly consistent across time up to 168 days after the collar placement (personal communication with Dr. Janice Chambers January 21, 2000).

HED evaluated pet collars that contained 3-9% ai chlorpyrifos, considered to be representative of these products, in DP Barcode D2532246 (Memorandum from D. Smegal to J. Rowland, March 1, 1999). These collars are Sulfodene Scratchhex Flea and Tick collar for cats 4306-16 and Zema 11 month collar for dogs 45087-40. Exposures were estimated assuming that one percent (0.01) of the active ingredient applied to the pet to be available for dermal exposure from handling flea collars. This assumption is based on the best professional judgement of the OPP/HED staff and is assumed to be an upper-percentile value. In addition, EPA-recommended default mean body weights of 70 kg for adults and 15 kg for children age 1-6 years of age were used to estimate dose.

Additional refinements were incorporated into this analysis to account for the duration of exposure (i.e., labeled efficiency of the product is 11 months or 330 days), and to account for the amount of chlorpyrifos that could be dermally absorbed through the skin of humans. A dermal absorption factor was used because the long-term dermal no-observed-adverse effect level (NOAEL) used to calculate MOEs is based on an oral two-year dog study and route-to-route extrapolation. This refinement assumes steady-state exposure to chlorpyrifos. Dermal absorption was estimated to be 3 percent based on the ratio of the oral lowest-observed-adverse effect level (LOAEL) of 0.3 mg/kg/day from the rat developmental neurotoxicity study (MRID Nos. 44556901, 44661001) to the dermal LOAEL of 10 mg/kg/day from the 21-day dermal study (MRID No. 40972801) for plasma and red blood cell cholinesterase inhibition. This absorption factor is comparable to the dermal absorption estimated from human data of 1-3% (MRID No. 00249203). The dose estimates and MOEs for two pet collar products for each age class are presented in Table 3.

To put the residential SOP screening level assessment into perspective, HED compared the preliminary data from Mississippi State to the residential SOP estimates of 1% available over 330 days (11 months). This comparison shows that daily vigorous contact with the collar, neck fur <u>or</u> back fur for approximately 2, 3 <u>or</u> 105 minutes, respectively for 330 days, would result in comparable exposures to those estimated using the residential SOPs. Therefore, the exposure estimates from the SOPs appear to be reasonable for contact times for the collar and neck fur and represent a central-tendency to high-end analysis.

(4) Residential Treatment for Subterranean Termite Control (MRID No. 40094001)

A study submitted by the registrant (MRID No. 40094001) was used to determine the respiratory exposures of the residents of homes treated with chlorpyrifos (approximately 0.6-1.3% ai Dursban TC) for subterranean termite control. Thirty one homes, 8 each of crawlspace, slab, and basement construction, and 7 plenum homes were treated at several different locations throughout the country. Applications were made by licensed professional applicators using conventional equipment and following the label instructions. Air in the kitchen, one bedroom, and the basements of basement construction homes was monitored before treatment and at various intervals after application for one year (i.e., during treatment, at 2, 4, 8, and 24 hours, 7, 30, and 90 days and 1 year post treatment). HED reviewed this study in memo from M. Firestone to D. Edwards, June 29, 1988, Reg/File # 464-562, EAB # 60271, 80628 and in memo from D. Smegal/T. Leighton to M. Hartman D266827, June 8, 2000). Appendix A presents the incremental time-weighted-average (TWA) air concentrations for the individual homes evaluated in this study.

Treatment of homes with chlorpyrifos for subterranean termite control appears to result in a slightly increased chlorpyrifos air concentrations over pre-treatment levels soon after treatment. More than half (55% or 17/31) of the homes had detectable chlorpyrifos air concentrations at levels ranging from <0.06 to 2.3 $\mu g/m^3$ before treatment. The highest pre-treatment concentration of 2.3 $\mu g/m^3$ measured in a slab house is higher than all the post-treatment 1 day maximum concentrations except for 3 homes (2 plenum and 1 slab which is the same house). Air concentrations return to pre-treatment levels within a few days after the application for slab, crawlspace, and the first floor rooms of basement homes for some homes. Basements showed higher concentrations of the chemical than first floor rooms. The concentrations in basements declined slowly over time, reaching first floor air measurement levels within one year after application. Treatment of plenum structures appears to result in airborne concentrations in first floor rooms that are slightly higher than those observed in other construction types. These increased levels return to pre-treatment levels within a few months after application.

Adults and children were assumed to be indoors in a residence (or treated buildings) for 16.4 and 20 hours per day, respectively. These exposure durations represents the 50th percentile for time spent at indoors for all individuals and the weighted average for children ages 1 to 6 years of age, respectively (USEPA 1997). Respiratory volumes for adults and children (13.3 and 8.1 m^3/day) were also obtained from USEPA (1997). The adult value is the average of males and females, while the child value is the weighted average for children ages 1-6 years. The resulting respiratory doses are presented in Table 4.

Table 4 presents the 90 day and 1 year incremental TWA concentrations with risk mitigation (i.e., reduction to 0.5% ai) and without risk mitigation. Based on the mitigation plan agreed to by the chlorpyrifos registrants in Jun 2000, HED calculated the incremental TWAs by adjusting the air measurements associated with a 0.6-1.3% ai product application to 0.5% assuming that there is a linear relationship between percent ai and resulting air concentrations. Both median values, along with the lowest and highest average from a single house are presented for the 7-8 homes per construction type. Both 90 day and 1 year incremental TWA concentrations were calculated for each house due to uncertainties in the toxicity endpoints. The 90 day and 1 year incremental TWAs represent an average concentration across rooms (i.e., kitchen, bedroom and basement) for each house, and across time periods (i.e., 1, 7, 30, 90 for 90 day TWA and 1, 7, 30 90 and 365 day average for 1 year TWA) for each house. HED used of one-half detection limit for non-detects in calculating both the 90-day and 1-year incremental TWA concentrations. This assumption may overestimate exposures slightly, particularly for the 1 year TWA estimates. However, this assumption is not likely to have a significant impact on the overall risk estimates, and has no impact on the homes with highest air concentrations (those homes had no non-detectable samples).

In order to evaluate the air concentrations exclusively associated with termiticide treatment, HED subtracted the pre-treatment air concentrations from the first seven days. In instances when the pre-treatment sample concentration was greater than any concentration in the first seven days, an air concentration of zero was assumed for the first seven days. The duration of 7 days was selected based on results from another DAS study that showed detectable chlorpyrifos air levels up to 7 days following crack and crevice treatment. The incremental TWA concentration was calculated by assuming a linear relationship of the air concentration between two sampling intervals (e.g., between day 7 and day 30).

As shown on Table 4, the median 90 day incremental TWA air concentrations, adjusted for applications using 0.5% ai, ranged from 0.1 to 0.14 $\mu g/m^3$, while the median 1 year incremental TWA air concentrations were slightly lower and ranged from 0.07 to 0.13 $\mu g/m^3$. The incremental TWA air concentrations prior to risk mitigation are also shown on Table 4, and are approximately two times higher than the mitigated air concentrations. There was considerable variability in air measurements, especially for plenum homes. For example, one plenum house had significantly higher air concentrations of 4.7 to 7.23 $\mu g/m^3$ up to 7 days, but less product (only 60 gallons) of a 1% ai solution was applied relative to the other plenum homes (90 to 200 gallons applied). Incomplete sampling data were available for the 7 plenum homes evaluated, where only 3 homes were sampled up to 1 year, 2 homes up to 90 days, and one each up to 7 or 30 days. HED notes that the plenum home for which sampling ceased at 7 days (P7) had the highest, 7-day average air concentration of any home in this study. Similarly, the plenum home for which sampling ceased at 30 days (P6) had the second highest 30 day average air concentration in the study. The registrant did not provide an explanation for the lack of air samples for these 4 plenum homes. The highest TWA air concentration measured at 1 year post application in this study was 0.46 $\mu g/m^3$ in a basement home.

Studies in the published literature measured air concentrations (average of kitchen and bedroom) of 1.38-3.13 $\mu g/m^3$ for crawlspace homes and 2.76-3.05 $\mu g/m^3$ for slab homes at 1 year postapplication (Wright et al. 1988). In comparison, the houses with the highest 1 year incremental TWA concentrations from the DAS study had levels of 0.477 and 0.433 $\mu g/m^3$ for crawlspace and slab, respectively which are significantly lower than the literature values. Average chlorpyrifos concentrations of 0.1 to 0.3 $\mu g/m^3$ were detected up to 8 years postapplication in slab and crawl homes (Wright et al. 1994). Higher air concentrations were detected in the bedroom, relative to the kitchen 8 years post application. However, these studies did not control for use of other chlorpyrifos products (i.e., lawn treatment, flea control, or other indoor uses, etc) (personal communication by D. Smegal with G. Dupree 5/17/2000), and therefore, may also overestimate potential exposures and risks associated with the termiticide use exclusively.

It should be noted that all of these studies only evaluate exposures resulting from treatment of soil outside the home, and do not evaluate the potentially higher exposures that could result from indoor treatment of a termite infestation (i.e., treating indoor exposed wood beams, baseboards, etc).

(5) Insecticidal Dust Products

No data are available to evaluate the postapplication residential exposures and risks associated with the use of insecticidal dust products indoors. In addition, there are no recommended procedures for evaluating these products in the Residential SOPs. Nevertheless, HED has concerns about the use of these products based on the relatively low MOEs calculated for residents or workers that could apply these products. HED recommends that the registrant provide additional information on the potential postapplication residential exposures associated with these products.

3.2.2 OUTDOOR POSTAPPLICATION EXPOSURES

(6) Lawn Treatment using a Liquid Spray (MRID No. 43013501)

Residential exposures following lawn treatment with a liquid chlorpyrifos spray were quantified based on a chemical-specific biomonitoring study submitted by Dow AgroSciences (MRID No. 43013501). HED's review of this study is presented in memo D197713 from D. Jaquith to L. Propst entitled "Review of study measuring environmental levels of and exposure to chlorpyrifos following lawn care treatment" dated June 17, 1996. In this study, eight volunteers performed activities intended to mimic a child walking/running, sleeping, crawling, and sitting on the turf following a broadcast treatment with 0.29 percent liquid chlorpyrifos spray (as Dursban Turf Insecticide). The insecticide was applied at the maximum label rate of 3 ounces per 1000 ft^2 or 4 lb ai/Acre. The activities were performed for a period of four hours, beginning when the turf had dried (four hours after application), however only two of the hours consisted of direct dermal contact with the lawn, while the other two hours were spent on a blanket. Exposures were monitored by measurement of urinary 3,5,6-TCP concentrations. Dislodgeable residues were monitored over the 48 hour period following drying of the turf, and were determined by dragging a weighted patch ("DOW Sled") over the treated surface at various time intervals. No data are available for further dissipation after 48 hours, making extended exposure analyses impossible. Due to the design of the biological monitoring study, it was not possible to derive separate exposure values for subsequent days.

The registrant attempted to address the issue of possible exposure of children through hand/oral contact following contact with a treated surface by washing the hands and assuming that all of the material rinsed from the hands was available for oral ingestion. The oral exposure, however, was adjusted for hand surface area (i.e., a child's hand is 41% of an adults hand). There are no quantitative data addressing the possible exposure via the hand/oral route currently available. The assumption was considered to provide a reasonable estimate of exposure via this route.

As shown on Table 3, for adults, the mean total estimated dose, corrected for baseline, is 6.3 μg/kg/day with a range of 3.5 to 10.1 μg/kg/day for a single exposure event immediately after drying of the treated turf. The extrapolated mean dose estimate for a 1-6 year old child is 10 μg/kg/day with a range of 7.9 to 13 μg/kg/day. This extrapolation to child may underestimate exposure because it neglects incidental ingestion of soil, and/or mouthing grass. Because there is no scientifically valid method to extrapolate from adult biomonitoring data to child exposure, HED segregated to biomonitoring data into inhalation, dermal and oral exposure. Details of this analysis are presented in the memo D197713 from D. Jaquith to L. Propst, June 17, 1996. Therefore, both total exposures based on biomonitoring results and route-specific exposures are used to evaluate this scenario.

HED also estimated potential exposures for the typical application rate of 1 lb ai/acre assuming that application rate and potential exposure are linearly correlated.

(7) Lawn Treatment using a Granular Product (MRID No. 44167101)

In addition, residential exposures following lawn treatment with chlorpyrifos were quantified for a granular insecticide (MRID No. 44167101). HED's review of this study is provided in memo D233282 from D. Smegal to M. Hartman entitled "Exposure of Individual to chlorpyrifos following Turf Treatment with a Granular Product", dated November 18, 1998. In this study, nine volunteers performed activities intended to mimic a child walking/running, sleeping, crawling and sitting on turf following application of a granular formulation of 0.5% chlorpyrifos at a rate of 1.8 lb active ingredient (ai) per acre. The activities were identical to those evaluated in the liquid lawn study discussed above. The activities occurred for a four hour period postapplication, although only two of the hours consisted of direct dermal contact with the lawn.

Absorption of chlorpyrifos was determined by monitoring the amount of metabolite 3,5,6-TCP excreted in the urine over an average of 5.5 days following exposure. Based on the biomonitoring and environmental data collected in this study, the mean total dose to 8 adults (4 male and 4 female), corrected for baseline exposure is 1.4 μg/kg/day with a range of 0.56 to 3.7 μg/kg/day. The extrapolated estimate of a child's dose (1-6 yrs old) based on the adult data is a mean of 2 μg/kg/day, with a range of 0.75 to 5.1 μg/kg/day. The method used to estimate exposures directly measures internal dose and does not differentiate between routes of exposure. This extrapolation to child may underestimate exposure because it neglects incidental ingestion of granules or soil.   Because there is no scientifically valid method to extrapolate from adult biomonitoring data to child exposure, HED segregated to biomonitoring data into inhalation, dermal and oral exposure. Details of this analysis are presented in the memo D233282 from D. Smegal to M. Hartman, November 18, 1998. Therefore, both total exposures based on biomonitoring results and route-specific exposures are used to evaluate this scenario.

In addition, the exposures may be underestimated for individuals that follow the label because deposition measurements indicate that only 90% of the theoretical recommended label rate was applied to the field where exposure activity occurred. However, the amount applied is within the typical variation for the equipment used.

(8) Golf Course Uses

Chlorpyrifos is applied to golf course turf. No chemical-specific data were submitted by DAS to assess golf course postapplication activities such as mowing/maintenance and golfing.   According to the National Golf Course Superintendents Association (personal communication with Mark Hartman, SRRD) the wettable powder formulation is by far the most used formulation and the granular formulations are not used often, if at all. The Association has mailed out a survey to their membership on use patterns (size of treated areas, number of applications, etc.) which they expect to complete shortly. In the interim, an assessment is provided for both the 1 and 4 lb ai/acre rates for both the liquids and wettable powders. Post application exposures to both mow/maintenance workers and golfers were assessed. The following assumptions are used in the preliminary assessment for applicators and postapplication exposures.

- Application rates: Dursban Turf Insecticide (EPA Reg. No. 62719-35) turf rates range from 1 lb ai/acre for ants, cutworms, sod webworm, etc. to 4 lb ai/acre for white grubs (specific directions to water in using ½ to 1 inch of water) and bluegrass billbugs.

- Adult and adolescent (age 12+ yrs) golfers weigh 70 and 44 kg, respectively and golf a 18-hole round of golf in 4 hours. Frequency of golf outings per year range from 10 for 5-17 yr olds to 43 for 65+ year olds (National Golf Foundation). The exposure duration was assumed to be short-term (i.e., less than 30 days) for direct contact with residues the day of treatment.

- Surrogate data from MRID 403407-10 (Moran et al. 1987. Exposure of workers and golfers to Flurprimidol from use of Cutless 50W on golf course turf. Eli Lilly and Company) are available for golfers (monitored wearing short-sleeved shirts, short pants, and socks) and mowers (shorts only) on golf courses. Data were monitored in this study on day after treatment (DAT) 0 and 1 for golfers and DAT 2, 4, 6 for mowers using passive dosimetry. The golfers (n=4) averaged 37 μg/hr on DAT 0 (range 28.1 to 46.9 μg/hr) and averaged 7.8 ug/hr on DAT 1 (range 6.9 to 8.6 μg/hr). The mowers exposure (n=1) was 28.1, 14.1, and 4.55 μg/hr on DAT 2, 4, 6, respectively. The application rate was 1.25 lb ai/acre. Exposures were corrected for field recoveries. The "unit" exposure approach to assess mowers and golfers using surrogate data in units of (μg/hr) / (lb ai/acre) assumes that the transfer of flurprimidol from turf would be similar to that of chlorpyrifos. Therefore, the dermal unit exposure of 37.5 (μg/hr) / (lb ai/acre) was used to assess golfers.

The exposures are presented on Table 3 for golfers and Table 6 for mow/maintenance workers. Table 5 presents the average turf transferable residues on day 1 after treatment. The highest average dislodgeable foliar residue of 0.414 $\mu g/cm^2$ was used to assess mow/maintenance workers for golf courses.

(9) Mosquitocide Uses

HED evaluated potential postapplication bystander exposure to chlorpyrifos from the mosquito control applications. Chemical-specific data are not available. Therefore, literature studies, the AgDrift Model (V1.0) that was developed by the Spray Drift Task Force, and the Residential SOPs were used to develop a screening-level assessment. The use of the literature and Ag Drift Model is consistent with the assessment that was developed in the fenthion RED. No proprietary data from the model library were used in this assessment. The purpose of these model calculations is to refine the turf deposition factor for aerial application of chlorpyrifos in mosquito control public heath treatments. Details of this analysis are presented in DP Barcode D263895, Updated Memorandum from J. Dawson and D. Smegal to S. Knizner and M. Hartman, March 8, 2000.

HED evaluated potential postapplication exposures to adults and child residents entering treated lawns following ground-based fogger Mosquitomist One ULV (EPA Reg. 8329-24) mosquito control uses. Potential exposures were estimated because of the concern for the residues that may be deposited during the ultra low volume (ULV) ground-based fogger applications in the vicinity of residential dwellings or other recreational areas (e.g., schools, playgrounds, parks, athletic fields). Exposure from ULV aerial applications of Mosquitomist One was evaluated and determined to be negligible. This assessment has been developed to ensure that the potential exposures are not underestimated and to represent a conservative model that encompasses potential exposures received in other recreational areas (e.g., school playgrounds, parks, athletic fields). The evaluated scenarios that could result in postapplication are as follows:

- Dermal exposure from residues deposited on turf (adult and child);
- Incidental non-dietary ingestion of residues deposited on lawns from hand-to-mouth transfer (toddler);
- Ingestion of treated turfgrass (toddler); and
- Incidental ingestion of soil from treated areas (toddler).

Chemical-specific data for mosquito uses are not available. Therefore, the equations and assumptions used for each of these four scenarios were taken from the updated Residential SOPs. Although the SOPs were initially developed for direct turf applications, the models are used in this assessment to determine if there is a potential concern using a screening level approach (i.e., tier 1). In addition to the use of the SOPs, the unique nature of the mosquito control uses requires additional information in determining the deposition rate of chlorpyrifos (i.e., amount of ai deposited on residential turf). The determination of the deposition rates are consistent with HED's assessment developed in the fenthion RED. It was assumed that 5% of the application rate of 0.01 lb ai/acre is the deposition rate of which 5% was assumed to be available for dislodging. Post application exposures for ground-based foggers were based on the day of application because it was assumed that adults and children could be exposed to turfgrass immediately after application. Other key assumptions for adults and children (1-6 yrs) include body weights of 70 and 15 kg, respectively, and mean dermal transfer coefficients (TC) representing high contact activity (e.g., playing and rolling on turf) of 14,500cm^2/hr and 5,200 cm^2/hr, respectively. These TC's are the calculated mean, based on the Jazzercize method, which is believed to result in upper percentile estimates of the transfer coefficient for this scenario. In addition, other assumptions based on the updated SOPs include: exposure time of 2 hours, finger surface area of 20 cm^2, frequency of finger contact with mouth 20 times/hour, 50% of the residues would be extracted from saliva, grass ingestion of 25 cm^2/day for toddlers, soil ingestion of 100 mg/day for toddlers, and 100% bioavailability from soil.

HED did not calculate airborne concentrations and complete an inhalation-based risk assessment because of the long-term infinite dilution that is anticipated in an outdoor application and based on the very low application rate. HED however, requests confirmatory air monitoring data immediately following ground-based fogger application due the potential concern for short-term inhalation exposures. The dose estimates for adults and children, by pathway, are presented on Table 3.

(10) Yard and Ornamental Sprays

Yard Application

The potential exposures associated with chlorpyrifos-containing yard and ornamental products were evaluated based on a comparison to the exposures associated with liquid and granular insecticidal products for turf (MRID No. 43013501, for liquid insecticide, and 44167101 for granular insecticide). Details of this evaluation are presented in HED Review DP Barcode D2532246 (Memorandum from D. Smegal to J. Rowland, March 1, 1999).

A typical yard and ornamental spray product recommends that a 5.3% ai chlorpyrifos product be diluted at a rate of 4 oz/15 gallons of water, and applied to 500 ft^2 of yard (Ortho® Lawn Insect Spray, EPA Registration No. 239-2423, 1996). In the absence of product density information, the density of water (8 lb/gal) was assumed to estimate a total application rate of 0.0265 lb ai /1000 ft^2 (1.15 lb ai/acre). Therefore, this product application rate is approximately 3.5 times less than the application rate for the liquid turf product of 0.0937 lb ai/1000 ft^2 (i.e., 4.1 lb ai/acre) (MRID No.43013501), and approximately 64 percent of the application rate for the granular product of 0.0413 lb ai/1000 ft^2 (MRID No. 44167101).

Another turf and ornamental product recommends that a 24.64% ai chlorpyrifos product be applied from 1.5- 6 oz/1,000 ft^2 of yard (Dursban® 2E, EPA Registration No. 9404-66). This product contains 2 lb ai/gallon of chlorpyrifos. Therefore, the product application rate would range from 0.023 to 0.0936 lb ai/1,000 ft^2 (1.0 to 4.1 lb ai/acre), which is similar to the liquid and granular turf application rates.

By analogy, therefore, exposures resulting from the use of these yard insect sprays are expected to be similar or less than those resulting from the lawn insecticides. Average doses for adults are expected to range from 1.4 to 6.3 μg/kg/day for a four hour exposure the day of product application, but only two hours consisted of direct dermal contact with the treated turf. Extrapolated mean doses to children are expected to range from 2 to 10 μg/kg/day. Exclusive ornamental use is expected to result in lower exposures; however, because the labels allow both yard and ornamental uses, the yard use (which results in the higher potential exposures) has been evaluated.

(11) Perimeter Treatment of Residences

The potential exposures to a child contacting treated soil and turf near the perimeter of a residence were evaluated using assumptions in the updated Residential SOPs, and chemical specific turf transferable residue data. Exposure estimates for soil ingestion, hand to mouth activity and dermal contact were assessed. Details of this analysis are presented in memorandum from T. Leighton to D. Smegal and M. Hartman, April 4, 2000, D264708. For this analysis, it was assumed that a 6-10 feet wide area around the house perimeter was treated with the maximum label rate of Dursban Pro (EPA 62719-166) of 4.35 lb ai/acre (10 gallons of 0.12% spray per 1,000 ft2) according to the label.

There is no activity information available to determine the probability of a child playing up against a treated residence. Although, DAS submitted a biomonitoring study that assessed exposures to treated turf, this study does not accurately reflect potential activity patterns or durations for potential contact adjacent to a building foundation. There is however, a chemical-specific study available to estimate the turf transferable residues that can be extrapolated to perimeter treatments. Therefore, a screening-level assessment was performed, using the updated Residential SOPs. However, because the 2 hour time frame of children playing outdoors (recommended in the SOPs) is not representative of playing up against a house, this assessment back calculates the number of hand-to-mouth activities, or exposure duration of dermal contact to reach a MOE of 1000 for a child. Solving for the number of hand-to-mouth activities yields 7 events, and solving for dermal contact exposure duration results in 8 minutes. Estimated exposures associated with incidental ingestion of soil are 0.00022 mg/kg/day.

3.2.3 SCIENTIFIC LITERATURE

A number of studies in the scientific literature have quantified the levels of chlorpyrifos in household dust, dermal wipes (from hands), air and soil samples from the residential environment. Environmental concentrations of chlorpyrifos in homes may result from indoor pesticide application, spray drift, track-in, or from redistribution of residues brought home on the farm/LCO/PCO workers clothing. Potential routes of exposure for children may include incidental ingestion and dermal contact with residues on carpets/hard surfaces and inhalation of vapor and airborne particulates. These residues may persist at low levels and the resulting exposures are of a potential chronic nature. Several studies have also conducted biomonitoring of the urinary metabolite 3,5,6-TCP. Because the biomonitoring results (i.e., urinary levels of 3,5,6-TCP) are attributable to both dietary and non-dietary sources, these studies are discussed in the risk assessment document, along with registrant-submitted biomonitoring data. Below is a summary of some recent studies that conducted environmental and/or biomonitoring measurements for chlorpyrifos in residences.

Gordon et al. (1999) recently published preliminary results of the National Human Exposure Assessment Survey (NHEXAS) conducted in Arizona. This study collected residential and environmental measurements of chlorpyrifos. Chlorpyrifos was detected in all media sampled, which include floor dust, dermal wipes, indoor air, sill wipes, personal air, outdoor soil from yards and foundation and outdoor air. Chlorpyrifos was detected in 88%, 65%, 54% and 36% of the floor dust, indoor air, sill wipe and dermal wipe samples, respectively. Chlorpyrifos was detected at maximum levels of 3.3 $\mu g/m^3$ in indoor air, 0.175 $\mu g/m^3$ in personal air monitors, 0.023 $\mu g/m^3$ in outdoor air, 48.5 $\mu g/m^2$ (119 $\mu g/g$) in floor dust, 6,890 $\mu g/m^2$ in dermal wipes from hands (or

544 μg per two hands), 16,100 $\mu g/m^2$ in sill wipes, 0.4 μg/g (ppm) in yard soil, and 85 μg/g (ppm) in foundation soil. While the maximum detected concentration for indoor air, and house dust were higher than other published studies, the median levels of 8 ng/m^3 and 0.16 μg/g, respectively were generally lower than the median values reported in Jacksonville Florida (up to 182 ng/m^3 and 4.7 μg/g, respectively), Springfield Massachusetts (<4.5 ng/m^3 for indoor air) (USEPA 1990, Whitmore et al. 1990), Brownsville, Texas (up to 24 ng/m^3 and 0.56 μg/g, respectively)(USEPA 1994, Mukerjee et al. 1997) or Wenstchee, Washington (0.56 μg/g for house dust)(Simcox et al. 1995). There was an excellent correlation between indoor air concentrations and corresponding dermal wipes from hands, but a relatively poor correlation between chlorpyrifos dust and dermal wipe levels. The authors concluded that there was a poor correlation between house dust levels and foundation or yard soil, which indicates that indoor levels are largely derived from indoor use rather than from lawn applications or infiltration of foundation-applied material through cracks and crevices.

Buckley et al. (1997) conducted residential environmental and biomonitoring measurements of chlorpyrifos during the spring and summer of 1993 in 18 nonsmoking adult residents in 9 homes of the Lower Rio Grande Valley (LRGV) near Brownsville, Texas. The 12 females and 6 males in the study had a median age of 42 years, and all individuals were of Hispanic ethnicity. Significant seasonal differences ($p \leq 0.01$) were reported for urinary 3,5,6-TCP concentrations, with higher levels detected in the summer relative to the spring. Indoor dust and air concentrations were significantly correlated and predictive of urinary 3,5,6-TCP, and were also higher in the summer than the spring. The frequency of 3,5,6-TCP detection in the spring and summer were 13/17 (77%) and 11/12 (92%), respectively. The median and maximum creatinine-adjusted 3,5,6-TCP levels were 1.9 and 6.4 ug/L, respectively for spring and 3.2 and 11 ug/L, respectively for summer. Median chlorpyrifos indoor air concentrations in the spring and summer were 6.9 ng/m^3 (n=6) and 8.3 ng/m^3 (n=5), respectively. Median house dust in the spring and summer were 299 ng/g and 556 ng/g, respectively for six homes measured in both seasons. The approximate ranges of detected levels were 80 to 2000 ng/g for house dust and 4 to 150 ng/m^3 for indoor air. All but two of the homes reported the use of various pesticides for treatment of cockroaches, but only one home reported the use of chlorpyrifos specifically the previous summer. The authors speculate that house dust may be a source of indoor air concentrations.

Simcox et al. (1995) collected house dust and soil samples in children's play areas in and around homes adjacent to apple and pear orchards during the 1992 spray season. In this literature study, chlorpyrifos levels in house dust were found in 98 percent (total 48 families) of the homes of farmers and farm workers. The mean value was 429 ng/g and samples ranged from nondetect to 3,585 ng/g. The house dust levels for the "reference" families (n=11, defined as not working in agriculture and more than 1/4 mile from orchards) averaged 168 ng/g and ranged from nondetect to 483 ng/g. The soil concentrations averaged 17 ng/g for the agricultural families (range nondetect to 234 ng/g) while the "reference" families averaged 11 ng/g (range nondetect to 39 ng/g). The house dust levels were monitored using a HVS-3 vacuum. This type of sampler may potentially overestimate the residues that are available in carpets for human exposure.

Bradman et al. (1997) also monitored house dust in homes along with hand wipe samples from children. The highest chlorpyrifos levels in house dust were found in farm worker residents. The results of the house dust are not reported here because the homes and surfaces monitored varied and contain small sample sizes. The values reported for chlorpyrifos residues on children's hands (ages 1 to 3) are ND, ND, 20, and 100 ng. Readers are referred to the article for a more in-depth review.

4.0 OCCUPATIONAL AND RESIDENTIAL RISK CHARACTERIZATION

Margins of exposure (MOEs) for occupational and residential exposure were calculated for short-term (one day to one month), intermediate-term (one month to several months), and long-term exposure (several months to lifetime), depending on the scenario. The MOE is calculated by dividing the NOAEL by the daily exposure. The NOAELs presented on Table 1 were used to calculate risks.

A margin of exposure (MOE) of 1000 does not exceed HED's level of concern for oral, dermal and inhalation exposures for all residential populations, including infants and children (including residents). This factor includes 10X for interspecies extrapolation, 10X for intraspecies variation and a 10X Food Quality Protection Act (FQPA) factor. A MOE for commercial PCOs of ≥ 100 for all routes of exposure does not exceed HED's level of concern.

A total MOE is also calculated because there is a common endpoint (i.e., cholinesterase inhibition). Route-specific data are available for the dermal, inhalation and oral routes of exposure, therefore, the following reciprocal MOE calculation is used:

$$MOE_{Total} \quad \frac{1}{\frac{1}{MOE_{(Oral)}} + \frac{1}{MOE_{(Dermal)}} + \frac{1}{MOE_{(Inhalation)}}}$$

4.1 Risk and Uncertainty Characterization of Handler Exposures

MOEs for occupational and residential handler exposure were calculated for short-, intermediate and long-term exposure. Table 2 presents the exposure scenarios and exposure calculations using the above data sources for the non-agricultural occupational uses of chlorpyrifos. Children are not included in this table since children would not be expected to apply this material, although they might be exposed after application.

(1) Indoor Crack and Crevice Treatment. The long-term MOEs for PCOs were calculated based on passive dosimetry measurements obtained from a chemical-specific registrant-submitted study in which 0.29% Dursban Pro® was applied using a 2-gallon, hand pressurized B&G sprayer. As shown on Table 2, the mean dermal and total MOEs are less than 100 and exceed HEDs level of concern (range from 17 to 59, with total MOEs of 13 and 45) for PCOs that could handle more than 0.02 lb ai per day (the average quantity in the study). Inhalation MOEs are above 100 (197 to 20,000), except for PCOs that handled the maximum quantity in the study (0.0684 lb ai) (MOE is 58). However, the total MOE is 4500, and does not exceed HED's level of concern if a minimal quantity of 0.0002 lb ai chlorpyrifos is handled. Risks were calculated for the full range of exposures evaluated in the registrant-submitted study because there is insufficient information available on the distribution of actual product used by PCOs during crack, crevice and spot treatments. It should be noted that these risk estimates are based on PCOs that wore a double layer of clothes, chemically-resistant boots and gloves and eye protection.

These risk estimates represent a central-tendency scenario because only two of the 15 worker replicates reflect the maximum recommended label concentration of 0.5%; an average of 0.29% chlorpyrifos (as Dursban Pro®) was handled by the fifteen PCOs.   In addition, as noted previously, there was a large variation in exposure results due primarily to the range of chlorpyrifos ai handled (0.09 to 31.04 g), volume applied per replicate (0.02 to 2.8 gallons), sampling time (248 to 591 minutes or 4 to 9.85 hours), spray time (12 to 154 min) and percent chlorpyrifos handled (0.05 to 0.53%). In addition, it is possible that different tasks/activities associated with pesticide application in residential and commercial locations contributed to the range of exposures. However, the impact of applicator activities can not be determined due to an absence of study details.

In addition, because the registrant study only evaluated applicators, exposures to workers who mix/load and apply chlorpyrifos-products are likely to be higher than those assessed in this analysis.

The short-term exposures and MOEs for a resident that could apply a crack and crevice aerosol spray to their home were evaluated using PHED V1.1., in the absence of chemical-specific data. As shown on Table 2, the total MOEs are less than 1000 for the application of an entire 16 oz can of 1% ai or 0.5% ai chlorpyrifos (100 and 200, respectively), and therefore exceed HEDs level of concern. Dermal exposure contributes most to total exposure. These risk estimates are conservative, and assume that a resident will apply an entire 16 oz aerosol can in one day. In addition, HED evaluated a spot treatment, assuming the application of 2 oz of a 0.5% ai product. The resulting total MOE is 1600 and does not exceed HED's level of concern.

(2) Broadcast Turf Applications

<u>Lawn Care Professional</u>

The intermediate and long-term exposures and MOEs were based on a chemical-specific registrant-submitted study that evaluated exposures to 15 lawn care applicators based on both passive dosimetry measurements and biomonitoring of urinary TCP. In this study, chlorpyrifos was applied at 1 lb ai/acre, which is less than the maximum rate of 4 lb ai/acre for subsurface soil treatment. However, the rate of 1 lb ai/acre represents the typical/median rate used by the lawn care industry for surface soil treatments (Jefferson Davis Associates, Inc, 1999). The geometric mean dose estimate of 0.4 μg/kg/day, used in this assessment is based on the biomonitoring results, which measures the internal dose. However, because the biomonitoring data do not differentiate between route of exposure, only a total exposure estimate and MOE could be calculated. The total MOE of 75 for the lawn care applicator exceeds HEDs level of concern (i.e., less than 100). In addition, risks were calculated for potential chlorpyrifos exposure at the maximum label-recommended application rate of 4 lb ai/acre for subsurface soil treatment, because the study only evaluated an application rate of 1 lb ai/acre. This results in an approximate MOE of 20, which also exceeds HED's level of concern. These risks are based on workers that wore a single layer of clothes, chemically-resistant knee-high boots and gloves and a hat. Knee-high boots are not currently required on labels.

In addition, TruGreen/ChemLawn data (1999) for 193 workers indicate that the actual spray time LCOs is 2.75 hours with a total work shift work time of 8.48 hours, in contrast to the 1.5 hour spray time and 6 hour work day evaluated in this biomonitoring study. Consequently, the LCO exposure estimates are likely to be underestimated, based on real life work conditions.

Data submitted by TruGreen/ChemLawn (1999) indicate that LCOs handle chlorpyrifos-containing products at least 6 months (April to October). Therefore, it was assumed that the LCOs were exposed for both intermediate and long-term duration. The long-term toxicity endpoints were conservatively used to calculate the MOEs based on the biomonitoring results for applicators. However, the intermediate and long-term dermal endpoints, and long-term inhalation endpoints are identical (30 μg/kg/day) because they are based on the same studies.

Risks were also evaluated for a mixer/loader who could handle liquids using surrogate exposure data obtained from PHED, Version 1.1. As shown on Table 2, the total intermediate, and long-term MOEs for both the application rates (1 lb ai/acre and 4 lb ai/acre) when workers wear single or double layer clothes and gloves are equal to or above 100 (range from 100 to 820) and therefore, do not exceed HED's level of concern. Dermal exposure contributes most to total exposure. The MOEs for mixer/loader activities, which are based on route-specific PHED data, were calculated for both intermediate- and long-term exposures using the appropriate toxicity values (i.e., the intermediate and long term inhalation endpoints of 100 and 30 μg/kg/day, respectively). In conclusion, MOEs do not exceed HED's level of concern for mixer/loaders that wear the label-specified PPE.

Residential Applicator

The short-term total MOEs for residents that mix/load and apply chlorpyrifos to their lawns range from 6 to 150, and therefore exceed HED's level of concern for residents (MOEs less than 1000). This assessment evaluated both broadcast and spot treatment using the hose end sprayer, and low pressure handwand, respectively, and used exposure assumptions recommended in the Residential SOPs (12/18/97) because of the lack of chemical-specific information. This assessment evaluated both minimum and maximum application rates for residents that could apply from 1 to 22 gallons of diluted product in a day. All of the dermal MOEs were below 1000, and therefore, exceed HED's level of concern.

As noted previously, there is low confidence in dermal and inhalation unit exposure estimates for the hose-end sprayer scenario. In addition, there is low confidence in dermal unit exposure estimates, and medium confidence in the inhalation unit exposure estimates for the low pressure handwand. These MOEs are based on central tendency exposure estimates of the unit exposure, area treated, and body weight, and a central to upper-percentile assumptions for the application rate recommended in the Residential SOPs. Therefore, these MOEs are considered to be representative of central tendency to high-end estimates.

(3) Golf Course Use. Risks were evaluated for a mixer/loader who could handle liquids or wettable powder for golf course application using surrogate exposure data obtained from PHED, Version 1.1. As shown on Table 2, the total short-term MOEs for the typical application rate of 1 lb ai/acre for liquids, in addition to the application rate of 4 lb ai/acre for wettable powder in water soluble bags are equal to or above 100 (range from 100 to 400), and therefore, do not exceed HED's level of concern based on PHED data. However, the MOEs for the maximum application rate of 4 lb ai/acre for liquids are below 100 (MOE=26) and therefore, exceed HED's level of concern. For workers who mix/load and apply chlorpyrifos via a handgun to greens and tees, the short-term MOEs are above 100 (MOE=140) for the typical rate but below 100

(MOE=36) for the maximum application rate. MOEs for groundboom application were below 100 for both the typical and maximum rate based on biomonitoring data (MOE = 15-63), but were above 100 for the typical rate based on PHED data (MOE = 170). HED has more confidence in the MOEs based on biomonitoring data. In conclusion, the MOEs exceed HED's level of concern at the maximum rate of 4 lb ai/acre for all scenarios, and at the typical 1 lb ai/acre rate for groundboom applicators based on biomonitoring data. However, MOEs do not exceed HED's level of concern for golf course workers who mix/load or mix/load and apply chlorpyrifos liquid to greens and tees at 1 lb ai/acre, or apply wettable powders at 1 or 4 lb ai/acre.

(4) Ready-to-Use Formulated Product. The short-term doses and MOEs were based on a chemical-specific registrant-submitted study that evaluated exposures to 15 homeowners based on both passive dosimetry measurements and biomonitoring of urinary TCP. The geometric mean of the lognormally-distributed dose is estimated to be 0.24 μg/kg/day. This assessment is based on the biomonitoring results, which are considered to be more reliable that the passive dosimetry results. However, because the biomonitoring data do not differentiate between route of exposure, and the short- and intermediate-term toxicity endpoints are different for dermal and inhalation exposure, the passive dosimetry results were used to segregate the total exposure estimate. As discussed previously, based on the dosimetry data approximately 88% of the total dose was from dermal exposure, while approximately 12% was from inhalation.

As shown on Table 2, the resulting absorbed dose estimates used in the risk assessment are 0.029 µg/kg/day for inhalation and 0.21 µg/kg/day for dermal. For short-term scenarios (such as residents), the absorbed dermal dose estimate was further adjusted to an estimated dermal dose (non-absorbed) of 7 µg/kg using a 3% dermal absorption factor for direct comparison with the short-term dermal toxicity endpoint. The resulting combined dermal and inhalation MOEs are below 1000 for a resident (590), and therefore exceed HED's level of concern. In addition, the total biomonitoring dose was compared directly to the adjusted dermal absorbed NOAEL of 150 µg/kg/day (5000 µg/kg/day * 0.03). The dermal NOAEL was used because the majority of exposure is via this route of exposure. The MOE based on a direct comparison to the total biomonitoring dose is 625 and therefore, also exceeds HED's level of concern. These exposure estimates represent a central-tendency to high-end scenario for residents, who are more likely to apply one bottle of product rather than five bottles (i.e., one hour application) in a given day, but could wear shorts, rather than long pants. In the study, the long pants worn by the study participants contained up to 70% of the residues that comprised total dermal exposure.

(5) Insecticidal Dust Products. Due to an absence of chemical-specific data the exposures and risk estimates resulting from use of insecticidal dust products were evaluated using a scientific study that provided exposure estimates (i.e., deposition) per quantity of dust product handled. As discussed previously, the data were normalized for chlorpyrifos exposure. As shown on Table 2, the short-term MOEs for both residents and utility workers (i.e., treating underground wires) that could apply dust products are below 100 and 1000, respectively, and therefore exceed HED's level of concern (250 for residents and 0.8 to 98 for workers depending on quantity handled and duration of exposure). These estimates could overestimate exposures and risks because they are based on a study that evaluated a 15-minute application of a 5% dust formulation to the garden (Kurtz and Bode 1985). The residential MOEs are central tendency to high end and assume the application of an entire 10 oz can of a 1% ai product. The worker MOEs are central tendency for application of a 4 oz can (7% ai), and high end for the application of a 100 oz container (7% ai) of dust product. Because the study did not measure inhalation exposure, the exposure estimates and MOEs do not account for this exposure pathway, which could result in an underestimation of risk.

(6) Granular Formulation by Hand. Due to an absence of chemical-specific data, the exposures and risks resulting from hand application of granular formulation were evaluated using data from PHED V1.1 and the residential SOPs. As shown on Table 2, the intermediate-term total MOE for a LCO (20-34) and the short-term total MOE for a resident (MOE= 17-80) are less than 100 and 1000, respectively and therefore, exceed HED's level of concern. The risk estimates are driven by dermal exposure. As noted previously, there is medium confidence in the unit exposure estimates from PHED that are based on a single study in which a test subject wearing chemical-resistant gloves spread the granular formulation around the outside of the residence and over 90 percent of the samples contained no detectable material.

(7) Granular Formulation Application with Belly Grinder. Due to an absence of chemical-specific data, the exposures and risks resulting from the belly grinder application of a granular formulation were evaluated using data from PHED V1.1 and the residential SOPs. As shown on Table 2, the total intermediate-term MOEs for a LCO (7-11) and the short-term MOEs for a residential applicator (MOE = 3-24) are less than 100 and 1000, respectively and therefore exceed HEDs level of concern. Even the spot treatment resulted in MOEs of concern (MOE = 24). The risks are dominated by dermal exposure. As noted previously, there is low and medium confidence in the dermal unit exposure estimates for LCOs and residents, respectively, and high confidence in the PHED inhalation unit exposure estimates used to evaluated LCOs and residents.

(8) Granular Formulation Application with Push-type Spreader. Due to an absence of chemical-specific data, the exposures and risks resulting from the push type-spreader application of granular formulation were evaluated using data from PHED V1.1 and the residential SOPs. As shown on Table 2, the total MOEs for both a LCO (54-92) (intermediate-term) and residential applicator (110) (short-term) are less than 100 and 1000, respectively and therefore exceed HEDs level of concern. The risk estimates are driven by dermal exposure. The inhalation MOEs for both LCOs and residents are 1150, and therefore do not exceed HEDs level of concern. As noted previously, there is low confidence in the dermal unit exposure estimates from PHED and high confidence in the PHED inhalation unit exposure estimates.

(9) Pre-Construction Termiticide Treatment. The long-term doses and MOEs were based on a chemical-specific registrant-submitted study that evaluated exposures to mixer/loader/applicators (M/L/A) and tarp pullers based on dermal passive dosimetry measurements and air monitoring. As shown on Table 2, the mean doses to M/L/A resulting from a 3 hour exposure resulted in MOEs that exceed HED's level of concern of 100 (range 15-33) regardless of clothing (one or two layers). (Note the label requires only one layer of clothing, and does not require forearm length gloves, as worn by the workers). The MOEs a tarp puller were also below 100 for a tarp puller that could contact 8 tarps in one day (as was done in the study), and exceeded HED's level of concern even when the worker wore forearm-length chemical resistant gloves (range of 39-87). However, the MOEs are above 100 for workers that could lay only one tarp (approximately 7 minute duration), with and without gloves (range from 310 to 690). These exposures and MOEs are considered low-end estimates for workers that wore a double layer of clothing and forearm length gloves (not required by the label) and central tendency estimates for the workers that wore single layer of clothing and forearm length gloves (only regular gloves required by the label). These data could underestimate risks to a worker that is exposed for more than 3 hours per day or applies a 2% dilution spray to treat utility poles and fences (because the study applied a 1% ai diluted product).

(10) Post-Construction Termiticide Treatment. The long-term doses and MOEs were based on a chemical-specific registrant-submitted study that evaluated exposures to 15 PCOs mixing, loading and applying a chlorpyrifos product based on both passive dosimetry measurements and biomonitoring of urinary TCP. Because the biomonitoring measurements were only available for 5 individuals, the risks were calculated using both biomonitoring and dosimetry results. As shown on Table 2, the arithmetic mean biomonitoring dose is 4.27 μg/kg/day and the resulting total MOE is 7 and therefore, exceeds HED's level of concern. The geometric mean absorbed dermal and inhalation dose estimates based on the passive dosimetry are 2.48 and 0.91 μg/kg/day, respectively. The dosimetry dose estimates also result in MOEs that exceed HEDs level of concern (range from 12 to 33, with a total MOE of 9). It should be noted that during application the workers wore the label-specified PPE which includes long pants, long sleeve shirt, chemically resistant gloves, eye protection, a hat and a half face-piece respirator in confined spaces. In addition, during mixing and loading the workers also wore a second layer of clothes or apron and chemically resistant boots. These dose estimates and MOEs are considered central-tendency values and exclude exposure to a worker whose hose broke during the study, resulting in a dose that was ten times greater than the mean dose of the other 14 workers. In addition, these risks could underestimate exposures to workers that handle more concentrated solutions of 2% allowed on the label to treat utility poles and fences because the workers in the study applied a 1% diluted product.

(11) Paint Brush Applications. Due to an absence of chemical-specific data, the exposures and risks resulting from a paintbrush application to treat insect-infested wood by a resident were evaluated using data from the residential SOPs for both a worst case (1 gallon product) and typical scenario (1 quart product). As shown on Table 2, the total short-term MOEs for both scenarios are below 1000 (35 and 140, respectively) and therefore, exceed HED's level of concern. The risks are dominated by dermal exposure. There is low to medium confidence in the dermal unit exposure estimates and medium confidence in the inhalation unit exposure estimates. The unit exposure estimates recommended by the residential SOPs are central tendency (i.e., unit exposure values and body weight). Therefore, the MOEs for the typical case of 1 quart are considered to be a central tendency values, while the worst-case estimates are considered to be high end values.

(12) Ornamental Application. The exposures and risks to residents during the mixing/loading and application of chlorpyrifos to ornamentals were evaluated using the residential SOPs, due to an absence of chemical-specific data. As shown on Table 2, the total short-term MOEs based on application via the low pressure handwand and hose end sprayer are below 1000 (range from 8 to 270), and therefore exceed HED's level of concern. In addition, the total MOE is less than 1000 (880) even when the minimum rate (1 oz product/3 gallons of water) is applied to ornamentals via the hose end sprayer. These estimates are considered central tendency to high-end values. As noted previously, there is low confidence in dermal and inhalation unit exposure estimates for the hose-end sprayer. For the low pressure handwand, there is low confidence in dermal unit exposure estimates, and medium confidence in the inhalation unit exposure estimates.

(13) Mosquitocide Mixer/Loader/Applicator. Due to an absence of chemical-specific data, the exposures and risks resulting from mixing/loading and applying chlorpyrifos-products for the control of mosquitoes were evaluated using data from PHED V1.1. As shown on Table 2, both aerial and groundboom application scenarios were assessed for both short- and intermediate term durations, with two different application rates of 0.005 lb ai/acre and 0.01 lb ai/acre for ground-based fogger scenarios and only one rate of 0.023 lb ai/acre assessed for aerial scenarios.

For the aerial application scenarios (mixer/loader and applicator assessed separately), MOEs are above 100, and do not exceed HED's level of concern only for short-term durations that include engineering controls (MOE range from 160 to 240). MOEs are below 100 for intermediate-term mixer/loader (MOEs 14 to 43) and intermediate-term applicators (MOE 71), even with the use of engineering controls.

For ground-based fogger scenarios, MOEs are above 100 for short- and intermediate term mixer/loaders wearing PPE and handling 0.005 lb ai/acre, and for short-term exposures at the higher rate of 0.01 lb ai/acre (MOEs range from 133 to 280). With engineering controls, the intermediate-term ground-based fogger mixer/loaders handling the higher rate of 0.005 lb ai/acre were above 100 (MOE 250). For ground-based fogger applicators, MOEs were above 100 for both short- and intermediate term exposure durations using both application rates (0.005 and 0.01 lb ai/acre) when engineering controls were employed (i.e.,closed systems and/or enclosed cab/cockpit) (MOEs range from 100 to 560).

As noted previously, this assessment should be considered to provide screening-level estimates. Uncertainties arise from: (1) extrapolation of agricultural exposure data for similar uses related to mosquitocide uses (i.e,. mixer/loader and application of liquid products), (2) the large number of acres treated (i.e., 7500 acres for aerial and 3000 acres for ground-based fogger application), (3) frequency of use and exposure to workers, and (4) surrogate ground-based fogger exposure data are not available, and therefore, it was necessary to extrapolate from airblast exposure data.

4.2 <u>Risk and Uncertainty Characterization of Postapplication Exposures</u>

To calculate the potential risk to persons from postapplication exposures to chlorpyrifos HED used the NOAELs discussed previously. Average body weights of 70 and 15 kg were assumed for adults and children, respectively. As noted previously, the registrant submitted four studies addressing residential postapplication exposures. These studies were used to estimate exposures and risks to residents. One study evaluated residential exposures following crack, crevice and spot treatment of the kitchen and bathroom for cockroach control. Two additional studies, evaluated lawn application (liquid and granular), while another study monitored air levels for one year following termiticide treatment. Where relevant, exposure estimates were based on biological monitoring data (i.e., lawn studies, crack and crevice study) and hand/oral exposure derived from handwash data (i.e., lawn studies). Other exposures were calculated based on environmental measurements (i.e., termiticide use). In the absence of data, the updated Residential SOPs (2000) were used to estimate exposures and risks. The risk estimates are presented in Tables 3 and 4.

HED is in the process of revising the Residential Exposure Assessment SOPs. This process may identify specific areas of further concern with respect to chlorpyrifos and exposure to the general population. For example, some of the secondary exposure pathways that EPA is currently addressing include exposures resulting from residue tracked into homes from outdoor use, indoor dust, and spray drift. In a recent study, polycyclic aromatic hydrocarbons (PAHs) that are abundant in house dust were shown to increase the toxicity of chlorpyrifos in vitro, particularly at low levels (i.e., 2-50 μM PAHs with 1-180 nM chlorpyrifos-oxon, a metabolite of chlorpyrifos that inhibits acetyl cholinesterase) (Jett et al. 1999). Currently, there are no SOPs available to evaluate these potential exposure pathways. These scenarios however, may be evaluated in the future pending revisions to the residential SOPs.

There is insufficient use information and exposure data to assess exposure resulting from use in vehicles (i.e., planes, trains, automobiles, buses, boats) and other current label uses such as treatment of indoor exposed wood surfaces, supermarkets, restaurants, theaters, furniture, and draperies. However, HED has concern for these uses based on the scenarios assessed within this document. Therefore, additional exposure data are requested from the registrant for all uses not evaluated in this assessment.

In summary, all postapplication nonoccupational scenarios evaluated result in MOEs below 1000 and therefore, exceed HED levels of concern with the exception of golfers that could contact treated golf course turf treated at the typical rate of 1 lb ai/acre. In addition, the only post-application worker scenario evaluated, mow/maintenance workers for golf courses, results in MOEs above 100, and therefore, does not exceed HED's level of concern.

(1) Crack and Crevice Treatment of Kitchen and Bathroom (Inhalation Exposure for Treated Rooms). The risks to residents following crack and crevice and spot treatment were evaluated based on a chemical-specific registrant-submitted biomonitoring study that evaluated treatment in the kitchen and bathroom. In this study, biomonitoring results were within the typical pre-exposure baseline levels, however, adults were only in the house approximately 12 hours per day, and this could underestimate the potential exposure to children that spend more time at home or in other treated rooms (i.e., daycare centers, schools, etc). HED concluded that the dermal and oral doses for untreated rooms were negligible based on dislodgeable residue data and toy wipe samples in rooms adjacent to treatment. No dislodgeable residue data were available for treated rooms. Therefore, only passive dosimetry inhalation dose estimates based on air sampling were available for treated rooms. As shown on Table 3, short-term inhalation MOEs for doses following crack and crevice treatment range from 560 to 670 for adults to 130 to 360 for children for treated rooms. All of these inhalation MOEs exceed HED level of concern of 1000. The inhalation risk estimates for up to 10 days may be conservative because they are compared to a 90 day inhalation NOAEL.

The Dow AgroSciences study only evaluated exposures following treatment of the kitchen and bathrooms, while the label for this and similar products allow use in bedrooms, living rooms, closets, schools, day care centers, etc that could result in higher risks to children. Only air measurements were available for the treated rooms. No dislodgeable residue data were available from treated rooms. Also the Dow study only evaluated small hard ball toys, and not plush toys that could possibly act as a sink for chlorpyrifos (as shown in the published literature). In addition, the study only evaluated use of 0.5% Dursban Pro, which could underestimate exposure because the label recommends concentrations up to 1% for the control of wood-infesting insects on wood surfaces, wall voids, and voids and channels in damaged wood.

Low air concentrations were still present 10 days post treatment, however the current labels allow re-treatment every 7 days. In one house, the highest daily average air concentrations were detected on day 6 indicating possible sinks, or resuspension. This study has not yet addressed the possible cumulative effects of multiple treatments over time. In response to HED concerns, the registrant submitted additional analysis of the same air measurements to demonstrate that the potential for cumulative effects was minimal. HED however, believes additional data are necessary to alleviate our concerns pertaining to frequent indoor re-treatments. HED requests treated room residue data for floors, furniture and other surfaces available for contact by children for both chlorpyrifos, and its primary degradation metabolite, 3,5,6-TCP following multiple treatments, in addition, to chlorpyrifos air measurements in treated rooms following multiple treatments (i.e., at a minimum 3 treatments 7 days apart). Residue data for 3,5,6-TCP are important due to the potential for accumulation and persistence of this environmental degradate.

(2) Crack and Crevice Treatment of Other Rooms (Dermal and Oral Exposure in Untreated Rooms). Because the registrant-submitted study does not adequately address exposures associated with all the uses listed on this and similar product labels, HED also evaluated exposures using the Residential SOPs in conjunction with residue data from this biomonitoring study. The resulting dermal and oral MOEs are greater than 1000, and therefore do not exceed HED's level of concern. The dermal and oral SOP-calculated values are likely to underestimate risks because they are based on untreated room deposition measurements, and more refined and realistic exposure assumptions from the updated SOPs (i.e., only 5% of the residue is available as dislodgeable residue, 50% of residue is extracted in saliva, more refined transfer coefficients).

Total MOEs were calculated by adding the treated room inhalation MOEs (from the air measurements) with the SOP-calculated dermal and oral MOEs (based on untreated room data). As shown on Table 3, the total MOEs range from 110 to 440 for adults and children, and are due primarily to inhalation exposure. As noted previously, the inhalation MOEs for up to 10 days may be conservative because they are compared to a 90 day inhalation NOAEL. These MOEs are below 1000 and therefore exceed HED's level of concern. Consequently, HED has concerns for all crack and crevice treatments, including treatments in schools, day care centers, playhouses or other rooms that children may occupy for extended periods of time.

(3) Pet Collar Uses. The residential SOPs were used to assess pet collar exposures due to an absence of chemical-specific data. Residential postapplication MOEs for both cat and dog pet collar products containing 3-9% ai chlorpyrifos are below 1000 for children (MOEs range from 140 to 530) if long-term exposure is assumed to occur exclusively through dermal exposure. MOEs for adults are below 1000 for dog collars (670) but above 1000 for cat collars (2500) based on the same assumptions. In the absence of data, a screening-level assessment was conducted to evaluate pet collar use using the Residential SOPs, which may over estimate the true exposure and risk. However, at this time HED does not have information that could further refine these estimates. This analysis also does not evaluate potential oral exposures that could result from incidental ingestion of residues from unwashed hands or from a child mouthing or chewing on the flea collar. However, most labels explicitly state that children should not be allowed to handle or play with the flea collar. In addition, based on professional judgement, inhalation exposure was considered to be negligible. Scientists at the Mississippi State initiated a study in April 1999 to evaluate exposures from pet collars containing chlorpyrifos (Personal communication D. Smegal with J. Scott Boone, Research Toxicologist, Center for Environmental Health Sciences, College of Veterinary Medicine, Mississippi State, March 17, 1999). Preliminary data from 12 dogs in this study demonstrate that dislodgeable residues are available from the collar, and fur from the neck and back areas in approximate ratios of 66:37:1 following very vigorous rubbing. Residues were fairly consistent across time up to 168 days after the collar placement (personal communication with Dr. Janice Chambers January 21, 2000). To put the residential SOP screening level assessment into perspective, HED compared the preliminary data from Mississippi State to the residential SOP estimates of 1% available over 330 days (11 months). This comparison indicates that daily vigorous contact with the collar for 2 minutes, neck fur for 3 minutes or back fur for approximately 105 minutes for 330 days would result in comparable MOEs to those estimated using the residential SOPs. This comparison demonstrates the "reasonableness" of the residential SOP estimates and daily contact to a dog's neck for 3 minute seems to be reasonable.

(4) Termiticide Treatment. Because of chlorpyrifos' extensive use as a termiticide, HED has provided a detailed summary of the uncertainties associated with the risk estimates for termiticide treatments. As noted previously, HED calculated incremental TWA air concentrations for the entire house, assuming an individual could be in any room. The MOEs were based on a chemical-specific registrant-submitted study that provided air measurements up to 1 year post treatment of four types of homes. MOEs were calculated by comparing the 90 day incremental TWA to the intermediate-term inhalation NOAEL of 100 μg/kg/day, and the 1 year incremental TWA concentration to the longer-term NOAEL of 30 μg/kg/day. Based on this assessment, risks from inhalation exposure was the primary concern. Based on the mitigation plan, the TWA concentrations were normalized to a reduced application rate of 0.5% ai. As part of risk characterization, the Agency evaluated risks for both intermediate and long-term exposures because of uncertainties in the toxicity endpoints for both durations.

Table 4 presents the chlorpyrifos air concentrations and the corresponding MOEs with and without risk mitigation measures. Appendix A presents the MOEs for the individual homes evaluated in this study. Children 1-6 years of age have higher potential exposures than adults, primarily because of a higher breathing rate per body weight, and data that indicate young children spend more time at home than adults. For children, all the 90-day median MOEs are greater than 1000 (median MOEs range from 1,900 to 3,800) with risk mitigation, and therefore do not exceed HED's level of concern. Only 5 of the 30 homes with sufficient data have estimated 90-day MOEs less than 1000 for children with risk mitigation. However, some of the 1-year median MOEs are below 1000 even with risk mitigation, and therefore exceed HED's level of concern (median MOEs range from 530 to 1,100). Twenty of the 30 homes with sufficient data have estimated 1-year MOEs less than 1000 for children with risk mitigation. As shown on Table 4, the lowest 90-day and 1-year MOEs for an individual house are 440 and 270, respectively with risk mitigation.

The median MOEs for adults were greater than 1000 for all housing types for both the 90-day and 1-year analysis with risk mitigation, and therefore, do not exceed the Agency's level of concern (MOEs range from 1,800 to 13,000).

The Dow AgroSciences study measured air concentrations for up to one year postapplication in four types of homes (n=7-8/house type). The median 90 day incremental TWA air concentrations, adjusted for 0.5% ai, ranged from 0.1 to 0.14 $\mu g/m^3$, while the median 1 year incremental TWA air concentrations were slightly lower and ranged from 0.07 to 0.13 $\mu g/m^3$. The incremental TWA air concentrations prior to risk mitigation measures are approximately two times higher than the mitigated air concentrations. There was considerable variability in air measurements, especially for plenum homes. The maximum one year incremental TWA average air concentrations (average across rooms, and across time and adjusted to 0.5% ai) ranged from 0.02 to 0.25 $\mu g/m^3$ among all 31 houses. Studies in the published literature measured air concentrations (average of kitchen and bedroom) of 1.38-3.13 $\mu g/m^3$ for crawlspace homes and 2.76-3.05 $\mu g/m^3$ for slab homes at 1 year postapplication (Wright et al. 1988). In comparison, the houses with the highest 1 year incremental TWA concentrations from the DAS study had levels of 0.477 and 0.433 $\mu g/m^3$ for crawlspace and slab, respectively which are significantly lower than the literature values. Average chlorpyrifos concentrations of 0.1 to 0.3 $\mu g/m^3$ were detected up to 8 years postapplication in slab and crawl homes (Wright et al. 1994). It is interesting to note, the higher air concentrations were detected in the bedroom, relative to the kitchen 8 years post application. However, these studies did not control for use of other chlorpyrifos products (i.e., lawn treatment, flea control, or other indoor uses, etc) (personal communication by D. Smegal with G. Dupree 5/17/2000), and therefore, may also overestimate potential exposures and risks.

It should be noted that all of these studies only evaluate exposures resulting from treatment of soil outside the home, and do not evaluate the potentially higher exposures that could result from indoor treatment of a termite infestation (i.e., treating indoor exposed wood beams, baseboards, void injections, etc).

There are however, a number of uncertainties in the risk assessment that arise from the following sources: choice of toxicological data used to establish the inhalation toxicity endpoint, chlorpyrifos air concentrations, and exposure assumptions. The most significant uncertainties will be discussed below.

<u>Toxicity Endpoints</u>: There are uncertainties associated with both the intermediate and long-term inhalation NOAELs used to calculate the MOEs. The intermediate-term NOAEL of 0.1 mg/kg/day is based on two 90-day inhalation studies, in which the rats were exposed 6 hours/day, 5 days/week (nose-only) to the highest attainable vapor concentration of chlorpyrifos (287 $\mu g/m^3$). HED could not identify an inhalation LOAEL because no adverse effects were noted at the highest dose tested. Therefore, HED selected an oral LOAEL of 0.3 mg/kg/day to use in the dose-response assessment. The 3 fold difference between the NOAEL and LOAEL, adds an extra buffer of safety to the intermediate-term inhalation endpoint for a total MOE of at least 3000. Although the inhalation route of exposure is ideal for this assessment, the exposure regimen does not fully mimic the potentially continuous inhalation exposure for children associated with a termiticide treatment (i.e., up to 20 hours/day).

The long-term NOAEL of 0.03 mg/kg/day is based on oral animal studies that observed cholinesterase inhibition at 0.2 to 0.3 mg/kg/day (the LOAEL). HED notes that the large difference between the NOAEL and LOAEL (i.e., factor of 6.7 to 10), adds an extra buffer of safety to the long-term inhalation endpoint. Therefore, relative to the LOAEL, the MOE is actually at least 6,000 to 10,000 for a target MOE of 1000. In addition, there are significant uncertainties associated with route-to-route extrapolation due to differences in pharmacokinetics. Following oral exposure, chlorpyrifos is absorbed in the gastrointestinal tract and is transported to the liver, where it can undergo biotransformation to a potent cholinesterase inhibitor (chlorpyrifos-oxon), and be further detoxified. However, following inhalation exposure, chlorpyrifos is absorbed directly into the systemic circulation and initially bypasses the liver. These pharmacokinetic differences may play an important role in the route-specific toxicity of chlorpyrifos. In the absence of inhalation pharmacokinetic data, it is difficult to predict whether use of an oral NOAEL would over- or under-estimate inhalation risks.

Air Concentrations: There are also a number of uncertainties associated with the chlorpyrifos air concentrations used to assess termiticide risks, which affect both the 90 day and 1 year MOEs calculations. Measured chlorpyrifos air concentrations may be overestimated because of use of other chlorpyrifos-containing products. For example, more than half (55% or 17/31) of the homes in the DAS study had detectable chlorpyrifos air concentrations prior to termiticide treatment, indicating that residents may have used other chlorpyrifos products in the home, or had a previous chlorpyrifos termiticide treatment. Several studies in the scientific literature reported chlorpyrifos air concentrations up to 8 years following termiticide treatments (Wright et al. 1988, 1994). However, these studies did not control for use of other chlorpyrifos products (i.e., lawn treatment, flea control, or other indoor uses, etc) (personal communication by D. Smegal with G. Dupree 5/17/2000), and therefore, may also overestimate potential exposures and risks associated with the termiticide use exclusively.

In addition, spills inside the home can contribute to higher airborne concentrations of chlorpyrifos. In the DAS study, one of the homes had elevated basement air concentrations because of a spill. The elevated basement measurements were excluded from the analysis (i.e., only kitchen and bedroom air data were used). This is considered reasonable because spills are likely to be an infrequent occurrence, and because pest control operators (PCOs) are trained to promptly clean spills that occur during application. However, possible applicator error, unreported, undetected or unremediated spills can contribute to air concentration measurements.

The available data suggest that temperature influences indoor chlorpyrifos concentrations resulting from termiticide treatments (i.e.,warmer temperatures are associated with higher concentrations). In the DAS study, 26 of 31 homes were from the South or warm climates. Therefore, it is possible that the air concentrations used in this assessment represent high-end estimates, that could overestimate exposures for treated houses in more temperate climates.

There are uncertainties associated with the incremental TWAs air concentration calculations. Based on the mitigation plan, HED calculated the incremental TWAs by adjusting the air measurements associated with a 0.6-1.3% ai product application to 0.5% assuming that there is a linear relationship between percent ai and resulting air concentrations. This assumption is considered reasonable, although it could under- or over-estimate the air concentrations associated with 0.5% a.i. product application. In addition, the 1-year incremental TWA concentration may be overestimated for two basement homes, because one year air concentration measurements were not available. HED assumed the 90 day air concentration remained constant from 90 to 365 days. This assumption only impacts two basement homes (B1 and B2), both of which had 1 year MOEs less than 1000, but 90 day MOEs greater than 1000.

Air concentration measurements were taken in a total of 31 houses following termiticide treatments. This limited number of houses is used to represent all houses in the US. There is inherent uncertainty in extrapolating from this limited sample size to the entire US. This may lead to an over- or underestimate of risk.

HED used of one-half detection limit for non-detects in calculating both the 90-day and 1-year incremental time-weighted averages (TWAs). This assumption may overestimate exposures slightly, particularly for the 1 year TWA estimates. However, this assumption is not likely to have a significant impact on the overall risk estimates, and has no impact on the homes with highest air concentrations (those homes had no non-detectable samples).

Exposure Assumptions. The assumptions used to estimate exposures are based on USEPA recommended values (Exposure Factors Handbook), and are designed to be conservative for the majority of the population. These estimates could be conservative for children that do not spend their entire day at home (i.e., those that attend day-care, pre-school, and/or school). This assessment assumed that children aged 1-6 years are exposed to chlorpyrifos air concentrations in a treated home for 20 hours/day, 7 days/week, for up to 1 year.

Summary: Based on the uncertainties described above, the 90 day risk estimates may be underestimated, while the 1 year risk estimates may be overestimated. As shown on Table 4, the lowest 90-day and 1-year MOEs for an individual house are 440 and 270, respectively and the highest estimates are 13,000 and 9,500, respectively with risk mitigation. Although some MOEs are less than 1000, there is an additional 3 to 10 fold buffer because of the difference between the NOAEL and the LOAELs. In addition, a number of conservative assumptions were incorporated into these MOEs, such as assuming that all children spend 20 hours/day, 7 days/week for up to 1 year in a treated home.

Mitigation measures will further reduce exposures and risk. For example, the removal of whole house barrier treatment addressed the exposures of most concern. It is expected that the limited spot and localized treatment, and pre-construction treatments would represent less exposure and risk.

Comments on Pre-Construction Treatment:

Based on the available data for post-construction treatment and best professional judgement, HED concludes that pre-construction termiticide treatments are likely to result in lower chlorpyrifos indoor air concentrations and risk. This conclusion is based upon the following:

(a) During pre-construction treatment, chlorpyrifos is applied to the soil and then is covered with a tarp, which would prevent volatilization into the house;
(b) Treatment occurs before the house is built, and it is expected that air concentrations will decline dramatically during the 3 to 12 months of house construction;
(c) New homes typically do not have cracks in the foundation that occur with settling to allow seepage into the house; and
(d) There is no potential for spills or seepage from the drill holes in the foundation or slab, which could contribute to higher air levels following post-construction treatment.

(5) Insecticidal Dust Treatment. No data are available to evaluate the postapplication residential exposures and risks associated with the use of insecticidal dust products indoors. In addition, there are no recommended procedures for evaluating these products in the Residential SOPs. Nevertheless, HED has concerns about the use of these products based on the relatively low MOEs calculated for residents or workers that could apply these products. HED recommends that the registrant provide additional information on the potential postapplication residential exposures associated with these products.

(6) Lawn Treatment with a Liquid Spray. A chemical-specific registrant-submitted biomonitoring study was used to assess residential exposure following lawn treatment with a liquid spray. As noted previously, because there is no scientifically valid method to extrapolate from adult biomonitoring data to child exposure, HED segregated to biomonitoring data into inhalation, dermal and oral exposure. Details of this analysis are presented in the memo D197713 from D. Jaquith to L. Propst, June 17, 1996. Therefore, both total exposures based on biomonitoring results and route-specific exposures are used to evaluate this scenario. The total short-term MOEs for adults and children exposed to lawn treated with 0.29% chlorpyrifos spray at the maximum rate of 4 lb ai/Acre range from 6 (5.6) to 24, and exceed HEDs MOE level of concern (i.e., MOE less than 1000). The dermal, inhalation and oral MOEs also exceed HEDs level of concern and range from 10 to 400.

Data recently submitted by Jefferson Davis Associates (1999) and TruGreen/ChemLawn (1999) demonstrate that the typical rate for surface-feeding insects is 1 lb ai/acre (although the maximum rate of 4 lb ai/acre is used for subsurface feeding insects). Therefore, it is possible that the MOEs for turf treated with the typical rate are approximately four times higher (approximate range from 30 to 96) than those estimated from the biomonitoring study data. Nevertheless, lawn exposures resulting from the typical rate are still anticipated to exceed HED's level of concern by a large margin.

(7) Lawn Treatment with a Granular Insecticide. A chemical-specific registrant-submitted biomonitoring study was used to assess residential exposure following lawn treatment for a granular insecticide. As noted previously, because there is no scientifically valid method to extrapolate from adult biomonitoring data to child exposure, HED segregated to biomonitoring data into inhalation, dermal and oral exposure. Details of this analysis are presented in the memo D233282 from D. Smegal to M. Hartman, November 18, 1998. Therefore, both total exposures based on biomonitoring results and route-specific exposures are used to evaluate this scenario. The total average MOEs for adults and children exposed to lawn treated with a 0.5% granular formulation of chlorpyrifos at a rate of 1.8 lb ai/acre range from 73 to 120, and also exceed HEDs MOE level of concern (i.e., MOE less than 1000). The dermal MOEs, which range from 90 to 190, contribute most to the total MOEs, and also exceed HEDs level of concern. The inhalation MOEs range from 330 to 400 while the oral MOE for children is 6000. As shown on Table 3, MOEs of 42 and 29 were estimated for the highest-exposed adult and child. Data recently submitted by Jefferson Davis Associates (1999) demonstrate that the typical (median) rate for a granular product is 2 lb ai/acre for treatment of subsurface soil insects. Therefore, this assessment is consistent with the typical rate used by industry.

It should be noted that the average MOEs are based on central tendency dose estimates the day of treatment from state-of-the art biomonitoring studies, and therefore are not conservative. In fact, HED has concerns that the MOEs could be underestimated for young children because both lawn studies did not adequately address incidental ingestion of soil/granules or the more frequent hand to mouth activity of children compared to adults. Oral exposures to children were estimated to be 41% of the residue on an adult’s hands (based on a surface area conversion) from a one-time washing. In addition, exposures could be underestimated in some instances because these lawn-care products are used in residential areas, playgrounds, recreational areas, school yards, and golf courses, etc., and it was assumed that a child could be exposed to only one treated turf for 4 hours per day (actual dermal contact time of 2 hours).

The Dow AgroSciences Studies (granular and liquid application) evaluated a 4 hour exposure immediately following treatment (or 4 hours after the liquid insecticide had dried). However, 2 of the hours were spent on a blanket (while sunbathing and picnicking). Also, due to the design of the biological monitoring studies, it was not possible to derive separate exposure values for subsequent days. Furthermore, transferable residue data were not available for the liquid lawn treatment beyond 48 hours after application, making extended exposure analyses impossible. In this study, there was no clear decline in residues during the 48 hours after the turf treated with liquid chlorpyrifos had dried, possibly because of technical problems associated with using a drag over a turfgrass medium. The registrant should conduct transferable residue studies on turf for a period of more than 48 hours and with more samples collected to allow the derivation of a regression for decline of transferable residues over time. In addition, HED requests residue data on lawns for 3,5,6-TCP.

(8) Golf Course Use. In the absence of chemical-specific data, the updated Residential SOPs, and surrogate exposure data from flurprimidol were used to assess chlorpyrifos post application exposure to mow/maintenance workers and golfers. The “unit” exposure approach to assess mowers and golfers using surrogate data in units of (ug/hr) / (lb ai/acre) assumes that the transfer of flurprimidol from turf would be similar to that of chlorpyrifos the day of treatment. As shown on Table 3, the resulting short-term MOEs for adult and adolescent golfers are less than 1000 (600 and 360, respectively) for the maximum label rate of 4 lb ai/acre, but are greater than 1000 (2,400 and 1,500, respectively) for the typical label rate of 1 lb ai/acre. Therefore, only the MOEs associated with the maximum label rate exceed HED's level of concern. Table 6 shows that the short-term MOEs for mow/maintenance workers are above 100 (110 to 210) and therefore, do not exceed HED's level of concern, even at the maximum label rate of 4 lb ai/acre. These risks are conservative because they assume contact with golf course turf the day of treatment.

(9) Mosquitocide Use. In the absence of chemical-specific data, the scientific literature, AgDrift Model and the updated Residential SOPs were used to assess chlorpyrifos as a mosquitocide. The resulting screening-level short-term MOEs for chlorpyrifos adult mosquito control uses indicate that MOEs are greater than 15,000 for all postapplication exposure scenarios for adults and toddlers for the ground-based fogger mosquito control applications. Exposure resulting from aerial applications of Mosquitomist One ultra low volume (U.L.V) were evaluated and determined to be negligible. HED requests confirmatory air monitoring data immediately following ground-based fogger application due to potential concern for short-term inhalation exposures.

(10) Yard and Ornamental Spray Treatment. By analogy, yard and ornamental spray products were evaluated and determined to result in comparable doses and short-term MOEs with the lawn care products based on label uses and application rates. Therefore, use of many of these products is likely to result in MOEs that exceed HEDs level of concern.

(11) Perimeter Treatment of Residences. As noted previously, the potential exposures to a child contacting treated soil and turf near the perimeter of a residence were evaluated using assumptions in the updated Residential SOPs, and chemical specific turf transferable residue data. Exposure estimates for soil ingestion, hand to mouth activity and dermal contact were assessed. Because the 2 hour time frame of children playing outdoors (recommended in the SOPs) is not representative of playing up against a house, this assessment back calculates the number of hand-to-mouth activities, or exposure duration of dermal contact to reach a MOE of 1000 for a child. Solving for the number of hand-to-mouth activities yields 7 events, and solving for dermal contact exposure duration results in 8 minutes. Estimated exposures associated with incidental ingestion of soil are 0.00022 mg/kg/day, which result in a MOE of 2,300, and therefore does not exceed HED's level of concern. These results are presented on Table 3. The probability of a child playing on turf immediately following perimeter treatments (i.e, same day) and exhibiting hand-to-mouth activity within 6-10 feet of the foundation is unknown. However, more than 7 hand-to-mouth events or 8 minutes of dermal contact with treated turf could result in potential exposures to children that exceed HED's level of concern.

4.2.3 SCIENTIFIC LITERATURE

The scientific literature results from Gordon et al. 1999, Buckley et al. 1997, Simcox et al. 1995, and Bradman et al. 1997 provide support for HED's concerns for the potential for children's exposure in the home as a result of residential and/or agricultural uses of chlorpyrifos. These studies confirm that chlorpyrifos is present in residential settings, where children can be exposed.

Table 2. Estimates of Exposures and Risks to Commercial Applicators and Residents Applying Chlorpyrifos in the Residential Environment								
Application Scenario	**Unit Exposure (μg/lb ai)**		**Lb ai Handled**	**Central Tendency Dose (μg/kg/day) (a)**		**MOE (b)**		
	Dermal	**Inhalation**		**Dermal**	**Inhalation**	**Dermal**	**Inhalation**	**Total**
(1) Indoor Crack & Crevice Treatment								
Long term PCO with PPE (double layer clothes, chemically-resistant boots and gloves, eye protection) (0.29% Dursban Pro, EPA Reg. 62719-166) (Hand pressurized B&G Sprayer) (c)	1790 (absorbed)	532	Mean = 0.02	0.51	0.15	59	200	45
			Min = 0.0002	0.005	0.0015	5900	20000	4500
			Max = 0.0684	1.75	0.52	17	58	13
Short-term Residential Applicator (SS, SP, no gloves) (Residential SOPs) (p) (EPA Reg 026693-00003 (1%), 239-2619 (0.5%); Low Pressure Handwand	220000	2400	0.01 (1%ai at 16 oz)	31.4	0.34	159	292	100
			0.005 (0.5% ai at 16 oz)	15.7	0.17	318	584	200
			0.00063 (0.5% at 2 oz)	1.96	0.02	2540	4700	1600
(2) Broadcast Turf Application (Intermediate and Long-Term for PCOs; Short-Term for Residential Applicators) (Dursban Pro diluted spray, EPA Reg. 62719-166 for PCOs and Dursban 1-12 Insecticide EPA Reg. 62719-56 for Residents)								
Applicator with PPE (d) (single layer clothes, chemically-resistant boots and gloves, hat)	NA	NA	Mean= 2.17 (1.57-2.95)	Total: 0.4 (biomonitoring) 1 lb ai/ac (j)		Biomonitoring: 75 (k)		
				1.6 (label max) (j) 4 lb ai/ac		Label Max: 20 (j, k)		
Mixer/Loader (liquid) (Single layer clothes, gloves)(i)	23	1.2	2.95 (l)	0.029(m) 1 lb ai/ac	0.05 (m) 1 lb ai/ac	1032	1980 (IT)	680 (IT)
							600 (LT)	380 (LT)
				0.116 (j) 4 lb ai/ac	0.2 (j) 4 lb ai/ac	260	500 (IT)	170 (IT)
							150 (LT)	100(LT)

Table 2. Estimates of Exposures and Risks to Commercial Applicators and Residents Applying Chlorpyrifos in the Residential Environment								
Application Scenario	Unit Exposure (μg/lb ai)		Lb ai Handled	Central Tendency Dose (μg/kg/day) (a)		MOE (b)		
	Dermal	Inhalation		Dermal	Inhalation	Dermal	Inhalation	Total
Mixer/Loader (liquid) (double layer clothes, gloves)(i)	17	1.2	2.95 (l)	0.021(m) 1 lb ai/ac	0.05 (m) 1 lb ai/ac	1400	1980 (IT) 600 (LT)	820 (IT) 420(LT)
				0.084 (j) 4 lb ai/ac	0.2 (j) 4 lb ai/ac	350	500 (IT) 150 (LT)	200 (IT) 100(LT)
Residential Mixer/Loader/Applicator Broadcast with Hose End Sprayer (SS, SP, no gloves) (Residential SOPs)	30000	9.5	0.5 22 gallons at (min. 3 oz/gal)	214 (f)	0.07	23	1470	23
			2 22 gallons at (max 12 oz/gal)	857 (f)	0.27	6	368	6
Residential Mixer/Loader/Applicator Spot treatment with Low Pressure Handwand (SS, SP, no gloves) (Residential SOPs)	100000	30	0.094 1 gallon at 12 oz/gal (max)	134 (f)	0.04	37	2490	37
			0.023 1 gallon at 3 oz/gal (min)	33.5 (f)	0.01	150	9960	150
(3) Golf Course Treatment (Short-Term for contact with residues the day of treatment) (Dursban Turf Insecticide, EPA Reg. 62719-35)								
Mixer/Loader (liquid) (Single layer clothes, gloves, open mixing)(i)	23	1.2	40 (1 lb ai/ac* 40 acres)	12	0.69	380	150	100
			160 (4 lb ai/ac* 40 acres)	53	2.7	95	36	26

Table 2. Estimates of Exposures and Risks to Commercial Applicators and Residents Applying Chlorpyrifos in the Residential Environment								
Application Scenario	**Unit Exposure (μg/lb ai)**		**Lb ai Handled**	**Central Tendency Dose (μg/kg/day) (a)**		**MOE (b)**		
	Dermal	**Inhalation**		**Dermal**	**Inhalation**	**Dermal**	**Inhalation**	**Total**
Mixer/Loader (wettable powder, water soluble packets) (Single layer clothes, gloves)(i)	9.8	0.24	40 (1 lb ai/ac* 40 acres)	5.6	0.14	890	730	400
			160 (4 lb ai/ac* 40 acres)	22	0.55	220	180	100
Groundboom Applicator (Single layer clothes, no gloves) (open cab) (i)	14	0.74	40 (1 lb ai/ac* 40 acres)	8	0.42	630	240	170
Biomonitoring data from MRID 42974501 based on open cab, coveralls over t-shirt and no gloves.	0.061 ug/kg/lb ai (absorbed dose from MRID 42974501)			Biomonitoring: 2.4		63		63
	14	0.74	160 (4 lb ai/ac* 40 acres)	32	1.7	160	59	43
	0.061 ug/kg/lb ai (absorbed dose from MRID 42974501)			Biomonitoring: 9.8		15		15
Mix/Load/Apply Handgun (greens/tees) (liquid) (i)	360	2.6	5 (1 lb ai/ac* 5 acres)	26	0.19	190	540	140
			20 (4 lb ai/ac* 5 acres)	100	0.74	49	130	36
(4) Ready-to-Use Formulated Product (Ortho Ant Stop) (n)								
Short-term Residential Applicator (SS, LP, no gloves) (screw top bottle)	NA	NA	7.3E-5	0.24 (biomonitoring)		Biomonitoring: 625		
				7	0.029	714	3,400	590

Table 2. Estimates of Exposures and Risks to Commercial Applicators and Residents Applying Chlorpyrifos in the Residential Environment								
Application Scenario	**Unit Exposure (μg/lb ai)**		**Lb ai Handled**	**Central Tendency Dose (μg/kg/day) (a)**		**MOE (b)**		
	Dermal	**Inhalation**		**Dermal**	**Inhalation**	**Dermal**	**Inhalation**	**Total**
(5) Insecticidal Dust Product (Shaker Can or Bulbous Duster)								
Residential Applicator (10 oz can of 1% ai chlorpyrifos; 2.83 g ai) (EPA Reg. 62719-66, 62719-54 and 192-171)								
Short-term Residential Applicator (SS, LP, no gloves)	2200000	NE	0.024	20 (f,o)	NE	250	NE	250
Worker (4 oz or 100 oz of 7% ai chlorpryifos; 7.91 or 198 g ai) (EPA Reg. 13283-17, Rainbow Kofire Ant Killer)								
Short-term Exposure (LS, LP, gloves)	2000000		0.024	51 (f,o) (4 oz)	NE	98	NE	98
				1275 (f,o) (100 oz)		3.9	NE	3.9
Intermediate-term Exposure (LS, LP, gloves)				1.5 (g,o) (4 oz)	NE	20	NE	20
				38 (g,o) (100 oz)		0.8	NE	0.8
(6) Granular Formulation (Hand Application) (PHED V1.1, Residential SOPs) (EPA Reg. 62715-14, 62715-210) (2 lb ai/acre; 1000 ft2)								
LCO (LS,LP, gloves) (intermediate-term)	71,000	470	0.0459	1.4 (g)	0.31	21	324	20
LCO (double layer clothing, gloves) (intermediate-term)	40,000	470		0.79	0.31	38	324	34
Residential Applicator (SS, SP, no gloves) (short-term)	430000	467		282 (f)	0.31	18	327	17
Residential Applicator (LP, LS, gloves) (short-term)	71,000	467		47 (f)	0.31	106	327	80

Table 2. Estimates of Exposures and Risks to Commercial Applicators and Residents Applying Chlorpyrifos in the Residential Environment								
Application Scenario	**Unit Exposure (μg/lb ai)**		**Lb ai Handled**	**Central Tendency Dose (μg/kg/day) (a)**		**MOE (b)**		
	Dermal	**Inhalation**		**Dermal**	**Inhalation**	**Dermal**	**Inhalation**	**Total**
(7) Granular Formulation (Belly Grinder) (PHED V1.1, Residential SOPs) (EPA Reg. 62715-14, 62715-210) (2 lb ai/acre; 0.5 acre)								
LCO (LS,LP, gloves) (intermediate-term)	9300	62	0.97	3.9 (g)	0.9	8	120	7
LCO (double layer clothing, gloves) (intermediate-term)	5,700	62		2.4	0.9	12.5	120	11
Residential Applicator (SS, SP, no gloves) (short-term)	110000	62		1520 (f) (0.5 acre)	0.9	3	120	3
			0.0459 (1000 ft2	72	2.8	69	36	24
(8) Granular Formulation (Push-type Spreader) (PHED V1.1, Residential SOPs) (EPA Reg. 62715-14, 62715-210)(2 lb ai/acre; 0.5 acre)								
LCO (LS,LP, gloves) (intermediate-term)	1270 (h)	6.3	0.97	0.5 (g)	0.09	57	1150	54
LCO (double layer clothing) (intermediate-term)	730 (s)	6.3		0.3	0.09	100	1150	92
Residential Applicator (SS, SP, no gloves) (short-term)	3000	6.3		42 (f)	0.09	120	1150	110
Termiticide Treatments (PCOs with PPE)								
(9) Pre-Construction (1.44% ai chlorpyrifos as Dursban TC, EPA Reg. 62719-47) (Long-term) (e)								
M/L/A (single layer clothes; forearm length gloves) (3 hour average exposure) (dosimetry)	NA	NA	NA	1.57	0.45	19	67	15
M/L/A (double layer clothes; forearm length gloves) (3 hour average exposure) (dosimetry)	NA	NA	NA	0.477	0.45	63	67	33

Table 2. Estimates of Exposures and Risks to Commercial Applicators and Residents Applying Chlorpyrifos in the Residential Environment								
Application Scenario	**Unit Exposure (μg/lb ai)**		**Lb ai Handled**	**Central Tendency Dose (μg/kg/day) (a)**		**MOE (b)**		
	Dermal	**Inhalation**		**Dermal**	**Inhalation**	**Dermal**	**Inhalation**	**Total**
Tarp puller (with forearm-length gloves) (dosimetry)	NA	NA	NA	1 tarp: 0.023	1 tarp: 0.021	1300	1400	690
				8 tarps: 0.177	8 tarps: 0.168	170	180	87
Tarp puller (without gloves) (dosimetry)	NE	NE	NE	1 tarp: 0.081	1 tarp: 0.015	370	2000	310
				8 tarps: 0.644	8 tarps: 0.122	47	250	39
(10) Post-Construction (1% ai chlorpyrifos as Dursban TC) (EPA Reg. 62719-47) (long-term) (r)								
Mixer/Loader/ Applicator (PPE =LS, LP, chemically resistant gloves, hat, eye protection and half facepiece respirator in confined spaces; during M/L: 2 layers clothes and chemically-resistant shoes)	NA	NA	10.72 (4-32.7)	biomonitoring: 4.3		7		7
				Dosimetry: 2.5	Dosimetry: 0.91 (no protection)	12	33	9
(11) Paint Brush (Residential SOPs) (Short-term) (Dursban 1-12 Insecticide, EPA Reg. 62719-56)								
Residential Applicator (SS, SP, no gloves)	230000	284	0.0416 (1 gallon)	140 (f)	0.17	37	590	35
			0.0104 (1 quart)	34 (f)	0.043	148	2300	140

Table 2. Estimates of Exposures and Risks to Commercial Applicators and Residents Applying Chlorpyrifos in the Residential Environment								
Application Scenario	**Unit Exposure (μg/lb ai)**		**Lb ai Handled**	**Central Tendency Dose (μg/kg/day) (a)**		**MOE (b)**		
	Dermal	**Inhalation**		**Dermal**	**Inhalation**	**Dermal**	**Inhalation**	**Total**
(12) Ornamental Application (Residential SOPs) (Short-term) (Dursban 1-12 Insecticide, EPA Reg. 62719-56)								
Residential Mixer/Loader/Applicator Low pressure Handwand (SS, SP, no gloves)	100000	30	0.013 (min. 1 oz/3 gal H20)	18.6 (f)	0.0056	270	18,000	270
			0.05 (typical 4 oz/3 gal H20)	71 (f)	0.021	70	4700	69
			0.416 (max. 1 qt/3 gal H2O)	594 (f)	0.178	8	560	8
Residential Mixer/Loader/ Applicator Hose End Sprayer (SS, SP, no gloves)	30000	9.5	0.013 (min. 1 oz/3 gal H20)	5.6 (f)	0.0018	900	57,000	880
			0.05 (typical 4 oz/3 gal H20)	21 (f)	0.0068	230	15,000	230
			0.416 (max. 1 qt/3 gal H2O)	178 (f)	0.0565	28	1800	28

Table 2. Estimates of Exposures and Risks to Commercial Applicators and Residents Applying Chlorpyrifos in the Residential Environment								
Application Scenario	**Unit Exposure (μg/lb ai)**		**Lb ai Handled**	**Central Tendency Dose (μg/kg/day) (a)**		**MOE (b)**		
	Dermal	**Inhalation**		**Dermal**	**Inhalation**	**Dermal**	**Inhalation**	**Total**
(13) Mosquitocide Mixer/Loader/Applicator (PHED V1.1) (Short and Intermediate-term) (Mosquitomist One EPA Reg. 8329-24) (t)								
Mixer/Loader--Aerial PPE is double layer clothes and gloves; engineering control is a closed system and single layer clothes and gloves	17 PPE	1.2 PPE	0.023/acre at 7500 acres	41.9	2.96	120 (ST)	34 (ST)	26 (ST)
				1.3	2.96	24 (IT)	34 (IT)	14 (IT)
	8.6 (Eng controls)	0.083 (Eng Controls)		21.1	0.21	236 (ST)	490 (ST)	160 (ST)
				0.63	0.21	47 (IT)	490 (IT)	43 (IT)
Mixer/Loader-- Ground-based fogger PPE is single layer clothes and gloves; engineering control is a closed system and single layer clothes and gloves	23 PPE	1.2 PPE	0.005/acre at 3000 acres	4.93	0.26	1010 (ST)	390 (ST)	280 (ST)
				0.15	0.26	200 (IT)	390 (IT)	133 (IT)
	23 PPE	1.2 PPE	0.01/ acre at 3000 acres	9.9	0.51	510 (ST)	190 (ST)	140 (ST)
				0.296	0.51	100 (IT)	190 (IT)	67 (IT)
	8.6 (Eng controls)	0.083 (Eng Controls)		---	---	---	---	---
				0.11	0.036	270 (IT)	2800 (IT)	250 (IT)
Aerial Applicator closed system and single layer clothes and no gloves	5 (Eng controls)	0.068 (Eng controls)	0.023/acre at 7500 acres	12.3	0.17	400 (ST)	600 (ST)	240 (ST)
				0.37	0.17	81 (IT)	600 (IT)	71 (IT)
Ground-based fogger Applicator closed system and single layer clothes and no gloves	19 (Eng controls)	0.45 (Eng controls)	0.005/acre at 3000 acres	4.1	0.096	1230 (ST)	1040 (ST)	560 (ST)
				0.12	0.096	250 (IT)	1040 (IT)	200 (IT)
			0.01/acre at 3000 acres	8.1	0.19	610 (ST)	520 (ST)	280 (ST)
				0.24	0.19	120 (IT)	520 (IT)	100 (IT)

SS= short-sleeves; LS = long sleeves; LP= long pants, SP = short-pants; IT = intermediate term; LT = long term.
NA = Not applicable

NE = Not evaluated
M/L/A = Mixer/Loader/Applicator

(a) Central Tendency dose presented, unless otherwise specified, where minimum or maximum amount handled is assessed. Range of exposure is presented in parentheses. Central Tendency dose (μg/kg/day) = central tendency unit exposure (μg/lb ai) * Lb ai handled * dermal absorption factor (intermediate and long term) / 70 kg body weight. Data from PHED is the "best fit" mean exposure (i.e., geometric mean for lognormal distributions, arithmetic mean for normal distributions and median for other distribution types).

(b) MOE = NOAEL/ Dose, where the acute oral NOAEL is 500 μg/kg/day (1 day); short-term dermal NOAEL is 5000 μg/kg/day (less than 30 days), intermediate- and long-term dermal NOAELs are 30 μg/kg/day (greater than 30 days), short- and intermediate inhalation NOAEL is 100 μg/kg/day (1-6 months), and long-term inhalation NOAEL is 30 μg/kg/day (greater than six months). Acceptable MOE $\geq$ 100 for commercial PCOs and $\geq$1000 for residents, which accounts for 10X for interspecies 10X extrapolation for intra-species variability and an FQPA factor of 10. Values rounded to two significant figures.

(c) Total MOE = 1 / [(1/MOE dermal) + (1/MOE inhalation)]

(d) Exposures based on MRID No. 444448-01 biomonitoring study of PCOs applying 0.29% ai chlorpyrifos wearing the label-specified PPE for crack and crevice applications; therefore no baseline is available. Dermal exposure already adjusted for 3% dermal absorption. The full range of exposures and MOEs are reported, because there is insufficient information available on the distribution of actual product handled by PCOs in the field.

(e) Exposures based on MRID No. 447294-01, biomonitoring study using 0.12 Percent Chlorpyrifos Spray with PCOs wearing the label-specified PPE for turf application; therefore no baseline is available.

(f) Exposures based on registrant study MRID No. 44589001. Average exposure for M/L/A is 3 hours. Average 7 min exposure for tarp pullers were multiplied by 8, to assume a worker could pull 8 tarps in a work day.

(g) Short-term dermal dose does not adjust for dermal absorption because the short-term dermal NOAEL of 5 mg/kg/day is based on a 21-day rat dermal study.

(h) Intermediate-term dermal dose was adjusted for absorption assuming 3% dermal absorption for comparison with the intermediate-term oral NOAEL of 0.03 mg/kg/day.

(i) Unit exposures from PHED were adjusted to account for an estimated 90% protection from gloves.

(i) In the absence of chemical-specific data, surrogate unit exposures obtained from PHED, Version 1.1 were used.

(j) The biomonitoring study applied the Dursban Pro diluted spray (EPA Reg. 62719-166) at a rate of 2 gallons diluted spray solution/1000 ft^2 (equivalent to 1 lb ai/acre), whereas the label recommends a maximum application rate of 4 lb ai/acre for subsurface soil treatment of white grubs. Therefore, the exposures were conservatively adjusted upwards by a factor of 4 (i.e., normalized to the maximum rate) to account for the difference in application rate.

(k) The exposure estimates were compared to the intermediate and long-term dermal and long-term inhalation NOAEL of 30 μg/kg/day based on information provided by TruGreen/ChemLawn (1999).

(l) Maximum quantity handled from biomonitoring study (MRID No. 44729401).

(m) Absorbed Dermal Dose (μg/kg/day) = Unit exposure (μg/lb ai) * amount handled (2.95 lb ai) * dermal absorption factor (0.03) / 70 kg body weight.

(n) Exposures based on biomonitoring data from MRID No. 44739301, using the geometric mean of 0.24 ug/kg. Passive dosimetry results were used to segregate exposure into dermal and inhalation components due to different toxicity endpoints (see text). Short-term dermal exposure was further adjusted using a 3% dermal absorption factor to obtain a dermal exposure estimate for comparison with the short-term dermal endpoint of 5000 ug/kg.

(o) Exposure estimates based on a study that evaluated the application of a dust product to a home garden (Kurtz and Bode 1985), where exposure was normalized for chlorpyrifos exposure. Exposures are predominantly dermal. See text.
Residential Handler Dose (μg/kg/day) =(deposition in study (4.9 mg/10 g ai carbaryl) * 2.83 g ai chlorpyrifos* 1000 μg/mg) / 70 kg
Worker Dose (μg/kg/day) =(deposition in study (4.5 mg/10 g ai carbaryl) * 7.91or 198 g ai chlorpyrifos* 1000 μg/mg) / 70 kg

(p) Exposure based on Residential SOPs, and assumes the application of a 16 oz aerosol can that contains 1% or 0.5% ai chlorpyrifos.

(q) Value based on the average amount of active ingredient handled in the 55 replicates of dispensing granular bait from the studies in PHED.

(r) Exposure estimates based on MRID No. 44729402. Biomonitoring results based on 5 individuals, dosimetry data based on 15 individuals.

(s) Dermal unit exposure could underestimate exposure because it excludes hand and neck exposure.

(t) Exposure (μg/kg/day) = unit exposure (μg/lb ai) * lb ai /acre handled * acres treated / 70 kg.

Table 3. Estimates of Postapplication Exposures and Risks to Residents/Recreational Users				
Reentry Scenario	**Central Tendency Dose (μg/kg/day) (a)**		**MOE (b)**	
	Adult (70 kg)	**Child (15 kg)**	**Adult**	**Child**
(1) Crack & Crevice Treatment of Kitchen and Bathroom (0.5% Dursban Pro EPA Reg. 62719-166) (c) (Short-term) (Inhalation Exposure)				
Maximum 1-Day Inhalation Exposure:	0.18 (0.075- 0.39)	0.76 (g)	560	130
10-Day TWA Inhalation Exposure	0.15 (g)	0.28 (g)	670	360
(2) Crack & Crevice Treatment Exposure in Untreated Rooms Using Residential SOPs (0.5% Dursban Pro, EPA Reg. 62719-166) (o) (Short-term) (Dermal and Oral Exposure)				
Dermal Exposure From Carpets (l)	2.56	3.68	1950	1360
Dermal Exposure From Surfaces (l)	1.28	1.84	3900	2700
Oral Exposure (f)	NE	0.123	NE	4100
Total Exposure (1 and 2) (Oral& Dermal untreated room and Inhalation in treated room)			390 (1 day max) 440 (10 day avg)	110 (1 day max) 240 (10 day avg)
(3) Pet Collar Uses (11 month efficiency) (long-term)				
Dog: Collar (EPA No. 45087-40; 3.44 g ai) (h)				
Dermal	0.045	0.21	670	140
Cat Collar (EPA No. 4306-16; 0.93 g chlorpyrifos) (h)				
Dermal	0.012	0.056	2500	530
(4) Post-Construction Termiticide Treatment (See Table 4)				
(5) Insecticidal Dust Products (Insufficient data to evaluate; see text)				
Broadcast Turf Application (Short-term)				
(6) Chlorpyrifos Spray (Dursban Turf Insecticide)				
0.29 Percent Chlorpyrifos Spray (4 lb ai/Acre) (d)				
Inhalation	0.59	5	170	20
Dermal (k)	510	414	10	12
Oral	NE	1.26	NE	400
Total Absorbed Dose	6.3 (3.5-10.1)	10 (7.9-13)	Average: 9 (m)-24 (i) Maximum: 5.6-15	Average: 7.5 (m)-15 (i) Maximum: 6-12
Chlorpyrifos Spray (1 lb ai/Acre) (d)				
Total Absorbed Dose	1.6	2.5	Average: 36-96	Average: 30-60

Table 3. Estimates of Postapplication Exposures and Risks to Residents/Recreational Users				
Reentry Scenario	Central Tendency Dose (μg/kg/day) (a)		MOE (b)	
	Adult (70 kg)	Child (15 kg)	Adult	Child
(7) Granular Formulation of 0.5% Chlorpyrifos (Dursban Insecticide) 1.8 lb ai/Acre (e)				
Inhalation	0.3	0.25	330	400
Dermal (k)	27	56	190	90
Oral	NE	0.085	NE	6000
Total Absorbed Dose	1.4 (0.56 - 3.7)	2 (0.75 - 5.1)	Average: 110 (i) - 120 (m) Maximum: 42-45	Average: 73 (m)- 75 (i) Maximum: 29
(8) Golf Course Use (Dursban Turf Insecticide; EPA Reg 62719-35) (1-4 lb ai/Acre) (Dermal Exposure) (Short-term) (p)				
Youth Golfer (12 yrs old, 44kg)	3.4 (1 lb ai/acre)		1500	
	14 (4 lb ai/acre)		360	
Adult Golfer (70 kg)	2.1 (4 lb ai/acre)		2400	
	8.4 (1 lb ai/acre)		600	
(9) Aerial and Ground-Based Fogger Adult Mosquitocide Application (Mosquitomist One EPA Reg. 8329-24) 0.01 lb ai/Acre (n) (short-term)				
Dermal	0.12	0.19	43,000	26,000
Oral (hand to mouth)	NE	0.0037	NE	13,000
Oral (Turfgrass Ingestion)	NE	0.0093	NE	54,000
Oral (Soil Ingestion)	NE	0.000025	NE	20,000,000
Total Exposure	0.12	0.2	43,000	15,000
(10) Yard and Ornamental Sprays (Evaluated based on analogy to Lawn Products; see text)				
(11) Perimeter Treatment of Residence (Dursban Pro label, EPA Reg. 62719-166) 4.35 lb ai/Acre (q) (short-term)				
Dermal	NE	See MOE	NE	8 minutes of play is equivalent to a MOE of 1000
Oral (hand to mouth)	NE	See MOE	NE	7 hand to mouth events is equivalent to a MOE of 1000
Oral (Soil Ingestion)	NE	0.00022	NE	MOE = 2300

NE = Not evaluated because exposure not of concern for adults
TWA = Time weighted average.
(a) Average dose presented, unless otherwise specified. Range of doses is presented in parentheses
(b) MOE = NOAEL/ Dose, where the acute oral NOAEL is 500 μg/kg/day (1 day); short-term dermal NOAEL is 5000 μg/kg/day (less than 30 days), intermediate- and long-term dermal NOAELs are 30 μg/kg/day (greater than 1 month) (absorbed dose), short- and intermediate inhalation NOAEL is 100 μg/kg/day (1day to 6 months), and long-term inhalation NOAEL is 30 μg/kg/day (greater than six months). Acceptable MOE $\geq$ 1000, which accounts for 10X for interspecies 10X extrapolation for intra-

species variability and an FQPA factor of 10X. Values rounded to two significant figures.

(c) MRID 44458201. Doses based on biomonitoring and environmental measurements.

(d) MRID 43013501. Doses based on oral, dermal and inhalation exposure based on biomonitoring and environmental measurements. Dose estimated for the day of application only. (See text). Child doses adjusted from original HED review to reflect 1-6 year old child (1.24 m3/day, 15 kg body weight and 0.41 child hand factor ratio relative to adult). Exposures and MOEs for 1 lb ai/acre based on biomonitoring data for 4 lb ai/acre, assuming that application rate and dose are linearly correlated.

(e) MRID 44167101. Oral, dermal and inhalation dose based on biomonitoring and environmental measurements. Dose estimated for the day of application only. (See text). Dermal absorbed dose from biomonitoring data adjusted to dermal exposure, assuming 3% absorption factor, for direct comparison with dermal NOAEL of 5000 ug/kg from rat dermal study.

(f) Oral hand to mouth dose (μg/kg/day) = available surface residue (0.02298 μg/cm2) * 0.05 (dislodgeable residue available)*0.5 (amount extracted in saliva) * surface area of fingers (20 cm2) * frequency of hand contact (20 events/hr) * exposure time (8 hrs/day) / body weight (15 kg for a child)

(g) Estimate based on the air concentrations detected in house #2, which were higher than those detected in houses #1 and 3. Example calculation: Dose (μg/kg/day) = (1.56 $\mu g/m^3$ (day 6) * 21 hr/24 hr * 8.3 m3/day) / 15 kg. The higher air concentrations of 1.7 and 2.3 $\mu g/m^3$ were not used because they reflect 6-8 hour and 60-72 hour measurements, respectively.

(h) Dose estimates modified from EPA Review DP Barcode: D253246 (D. Smegal to J. Rowland, March 1, 1999), based on body weight. Assumes 100% dermal exposure.

(i) Comparison of total biomonitoring dose to the short-term dermal absorbed NOAEL of 150 μg/kg/day (5000 μg/kg/day * 0.03 dermal absorption), because more than 70% of total exposure can be attributed to the dermal route.

(j) Mean dose is based on mean biomonitoring data. Assumes 100% inhalation exposure.

(k) Absorbed dermal dose readjusted to dermal exposure for direct comparison with the dermal NOAEL of 5000 μg/kg from the dermal rat study. Original HED review estimated absorbed dermal dose assuming a 1% dermal absorption factor.

(l) Dermal dose from carpet/surfaces (μg/kg/day) = [available surface residue (0.02298 μg/cm2) * 0.05 (dislodgeable residue available)* TC (cm2/hr) [16,700 for adults and 6,000 for children] * Exposure time (hr/day) [8 hrs/day for carpet and 4 hr/day for surfaces]] / body weight (70 kg for adults and 15 kg for a child).

(m) Total MOE = 1 / [(1/MOE inhalation) + (1/MOE dermal) + (1/MOE oral)].

(n) Doses and MOEs based on the application rate of 0.01 lb ai/acre. Long-term inhalation dose was considered to be negligible because of infinite dilution that is anticipated in an outdoor application and based on the very low application rate.

(o) Doses estimated using the highest deposition residue of 2.298 μg/100cm2 in the family room of house number (room adjacent to the treated kitchen). It was assumed that 5% of the residue is available as dislodgeable residue in accordance with the Residential SOPs.

(p) Assumes short-term dermal exposure. Daily dermal exposure dose (μg/kg/day) = [Golfer unit exposure from flurprimidol of 37.5 ((μg/hr)/(lb ai/acre)) x application rate (lb ai/acre) x Exposure Duration (hrs/-day)] / Body Weight (kg). Assumes equal dislodgeability from the turf based on best (only) data available. Where 12+ youth weighs 44 kg and an adult weighs 70 kg.   Golfer durations are assumed to be 4 hours for an 18-hole round of golf. Frequency of golf outings per year range from 10 for 5 to 17 year olds to 43 for 65+ year olds (Source: National Golf Foundation).

(q) See memo from T. Leighton to D. Smegal and M. Hartman, April 4, 2000, D264708.

Table 4 Indoor Chlorpyrifos Air Concentrations and Estimated Exposures and Risks to Residents After Subterranean Termite Control Treatment (a)						
Construction Type	**Median Air Concentration (Range) ($\mu g/m^3$) (b)**		**MOE (d)**			
			Without Risk Mitigation		**Reflecting Risk Mitigation to 0.5% ai**	
	0.6-1.3% ai	**Reflecting Risk Mitigation to 0.5% ai**	**Adult (70 kg)**	**Child (15 kg)**	**Adult (70 kg)**	**Child (15 kg)**
Crawlspace **(n=8)**						
90 day incremental TWA	0.23 (0.06-0.56)	0.11 (0.03-0.23)	Median: 3,500 (1,400-13,000)	Median: 1000 (400-3,800)	Median: 7,300 (3,300-25,000)	Median: 2,100 (950-7,200)
1 year incremental TWA(c)	0.25 (0.049-0.477)	0.13 (0.03 - 0.2)	Median: 940 (480-4,600)	Median: 270 (140-1,300)	Median: 1,800 (1,200-7,400)	Median: 530 (340-2,100)
Basement **(n=8)**						
90 day incremental TWA	0.17 (0.04-1)	0.1 (0.03-0.37)	Median: 7100 (760-19,000)	Median: 2,100 (220-5,400)	Median: 13,000 (2,100-30,000)	Median: 3,800 (600-8,700)
1 year incremental TWA(c)	0.12 (0.04-0.79)	0.07 (0.03-0.25)	Median: 2,700 (460-5,500)	Median: 770 (84-1,600)	Median: 3,800 (930-8,800)	Median:1,100 (270-2,500)
Plenum (n=6) (e)						
90 day incremental TWA	0.28 (0.066-0.95) (e)	0.14 (0.03 - 0.48) (e)	Median: 3,600 (810-12,000)	Median: 1,000 (230-3,400)	Median: 6,600 (1,600-22,000)	Median: 1,900 (460-6,400)
1 year incremental TWA(c)	0.16 (0.046-0.49) (e)	0.09 (0.02-0.25)(e)	Median: 1,500 (470-5,000)	Median: 430 (140-1,400)	Median: 2,600 (940-9,500)	Median: 760 (270-2,700)
Slab **(n=8)**						
90 day incremental TWA	0.19 (0.061-0.91)	0.12 (0.04-0.51)	Median: 4,100 (850 - 13,000)	Median: 1,200 (240-3,600)	Median: 6,600 (1,500-20,000)	Median: 1,980 (440-5,800)
1 year incremental TWA(c)	0.2 (0.05-0.43)	0.11 (0.03 - 0.24)	Median: 1,100 (530-4,700)	Median:330 (150-1,400)	Median: 2,100 (960-7,600)	Median: 600 (280-2,200)

(a) Estimates were derived from a registrant-submitted air monitoring study (MRID No. 40094001). Risk mitigation values adjusted to 0.5% ai. based on risk mitigation plan.

(b) Air concentrations from registrant study represent the incremental 90 day and 1 year time-weighted average concentrations based on the average of the kitchen, bedroom and basement (only for basement) air concentrations per time interval.

(c) Average of the 90 day (average of days 1, 7, 30, and 90) and 1 year (average of day 1, 7, 30, 90 and 1 year measurements, where available). For plenum homes, only 3 homes had 1 year measurements, two were sampled up to 90 days, and one each was sampled up to 7 or 30 days.

(d) MOE = NOAEL/ dose, where short- and intermediate-term inhalation NOAEL =100 μg/kg/day (used to assess 90 day and 1 day averages) and long-term inhalation NOAEL =30 μg/kg/day (used to assess 1 yr average). Acceptable MOE $\geq$ 1000, which accounts for 10X for interspecies extrapolation, 10X for intra-species variability and an FQPA factor of 10. Values rounded to two significant figures. Median MOE calculated from individual MOE values, and not from median air concentration. Dose calculated as follows: dose (μg/kg/day) = air conc ($\mu g/m^3$) * inhalation rate (m^3/day) * hours per day in house/24 hours * 1/body weight (kg). Assumptions are as follows: respiratory volumes of 13.3, and 8.1 m^3/day for a adults and 1-6 yr old child (average of male and female), respectively (Exposure Factors Handbook 1997 p. 5-24), and body weights of 70 and 15 kg, respectively. In addition, it assumes that adults and children spend 16.4 and 20 hours per day at home, respectively (Exposure Factors Handbook 1997 p.15-17, 15-147)

(e) For plenum homes, only 3 homes had 1 year measurements, two were sampled up to 90 days, and one each was sampled up to 7 or 30 days. The maximum 1 year concentration excludes the house with the highest concentration (i.e. on average 5.35 ug/m3) because samples were only collected up to 7 days. No reason was provided for lack of samples at other durations in houses with the highest air concentrations.

Table 5
Dislodgeable Transferable Residues for Golf Course Use

Formulation	Study Nominal Rate (lb ai/A)	Label Max Rate (lb ai/A)	DAT 0 Turf Transferable Residues (μg/cm2)			
			CA	IN	MI	Avg.
Dursban Pro	4.0	4.0	0.124	0.090	0.146	0.12
Dursban 50W	4.0	4.0	0.234	0.657	0.351	0.414
Dursban 2.5G	2.0	2.0	ND	ND	ND	ND
Dursban 1F	2.0	2.0	0.052	ND	ND	0.018

Table 6.
Chlorpyrifos Surrogate Occupational Postapplication Assessment for Golf Course Turf Treatment

Crop	Application Rate	DAT[a]	TTR from WP (μg/-cm^2)[b]	Mow/Maintain Transfer coefficient =500 cm^2/hr		Mow/Maintain Transfer coefficient =1,000 cm^2/hr	
				Potential Dermal Dose (mg/kg/day)	Short-term MOE	Potential Dermal Dose (mg/kg/day)	Short-term MOE
Golf Course Turf	4.0	0	0.414	0.024	210	0.047	110

Footnotes:-

a DAT is "days after treatment."

b Turf Transferable residues (TTR) from MRID 448296-01 based on average of CA, IN and MS sites following application of 4 lb ai/ Acre of Dursban 50W.

c Dermal Dose = [TTR ($\mu g/cm^2$) x Transfer coefficient (cm^2/hr) x conversion factor (1 mg/1,000) x 8 hr/day duration x 1 dermal absorption x 1/70 kg body weight. The target MOE of 100 is based on 10x interspecies and 10x intraspecies.

d Short-term MOE = NOAEL of 5 mg/kg/day / Potential dermal dose (mg/kg/day).

5.0 DATA NEEDS

HED could not evaluate the postapplication exposures and risks associated with use of insecticidal dust products due to an absence of chemical-specific data or recommended procedures in the Residential SOPs. Nevertheless, HED has concerns about the use of these products based on the low MOEs (i.e., 0.8 to 250) calculated using the surrogate data from the scientific literature for residents or workers that could apply these products. HED recommends that the registrant provide additional information on the potential post-application residential exposures associated with these products.

HED requests additional data for indoor crack, crevice and spot uses of chlorpyrifos. Specifically, HED requests <u>treated room residue data</u> for floors, furniture and other surfaces available for contact by children for both chlorpyrifos, and its primary degradation metabolite, 3,5,6-TCP following multiple treatments. Additionally, HED requests chlorpyrifos air measurements in treated rooms following multiple treatments (i.e., at a minimum 3 treatments 7 days apart). Residue data for 3,5,6-TCP are important due to the potential for accumulation and persistence of this environmental degradate.

HED requests confirmatory air monitoring data immediately following ground-based fogger application due to potential concern for short-term inhalation exposures.

In addition, HED requests exposure and/or environmental data for all registered products and/or uses that are not assessed in this risk assessment.

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APPENDIX A

POST-CONSTRUCTION TERMITICIDE ASSESSMENT

Table A-1
Estimates of Post-Application Risks to Residents from Post Construction Termiticide Treatment
0.6-1.3% ai Product Application

Home Type	90- Day Incremental TWA			1 Year Incremental TWA			Comments/ Fan Status
	Air Concentration ($\mu g/m^3$)	MOE (c) (NOAEL= 0.1 mg/kg/day)		Air Concentration ($\mu g/m^3$)	MOE (c) (NOAEL= 0.03 mg/kg/day)		
		Child (1-6 yrs)	Adult		Child (1-6 yrs)	Adult	
Basement- Style Construction							
B1-KS	0.334	670	2,300	0.248	270	930	on
B2-KS	1.013	220	760	0.793	84	290	off
B3-DC	0.052	4,300	15,000	0.054	1,200	4,300	off
B4-DC	0.068	3,300	11,000	0.0564	1,200	4,100	on
B5-GA	0.732	300	1,100	0.498	130	460	on
B6-GA	0.263	850	2,900	0.189	350	1,200	unknown
B7-MA	0.041	5,400	19,000	0.042	1,600	5,500	on
B8-MA	0.051	4,400	15,000	0.057	1,200	4,100	on
***Median* (d)**	**0.17**	**2100**	**7100**	**0.12**	**770**	**2700**	
Crawl Space-style Construction							
C1-GA	0.562	400	1,400	0.477	140	480	off, first 7 days set to 0
C2-GA	0.059	3,800	13,000	0.07	940	3,300	on
C3-TX	0.317	700	2,400	0.232	290	1,000	on
C4-TX	0.279	800	2,800	0.35	190	660	off, first 7 days set to 0
C5-GA	0.359	620	2,100	0.266	250	870	unknown
C6-GA	0.178	1,200	4,300	0.259	260	890	unknown
C7-TX	0.061	3,700	13,000	0.049	1,300	4,600	on, first 7 days set to 0
C8-TX	0.07	3,200	11,000	0.05	1,300	4,600	on
***Median* (d)**	**0.23**	**1000**	**3500**	**0.25**	**270**	**940**	
Slab type Construction							
S1-TX	0.179	1,200	4,300	0.2	330	1,100	on
S2-TX	0.165	1,300	4,700	0.21	320	1,100	off
S3-TX	0.2	1,100	3,900	0.20	330	1,100	on
S4-TX	0.165	1,300	4,700	0.14	480	1,700	off

Table A-1
Estimates of Post-Application Risks to Residents from Post Construction Termiticide Treatment
0.6-1.3% ai Product Application

Home Type	90- Day Incremental TWA			1 Year Incremental TWA			Comments/ Fan Status
	Air Concentration (μg/m^3)	MOE (c) (NOAEL= 0.1 mg/kg/day)		Air Concentration (μg/m^3)	MOE (c) (NOAEL= 0.03 mg/kg/day)		
		Child (1-6 yrs)	Adult		Child (1-6 yrs)	Adult	
S5-TX	0.061	3,600	13,000	0.05	1,400	4,700	off, first 7 days set to 0
S6-TX	0.374	590	2,100	0.43	150	530	off, first 7 days set to 0
S7-TX	0.91	240	850	0.2	330	1,200	off
S8-TX	0.22	1,000	3,500	0.137	490	1,700	off
***Median* (d)**	**0.19**	**1200**	**4100**	**0.2**	**330**	**1100**	
Plenum-style Construction							
P1-CA	0.615	360	1,300	0.228	290	1,000	---
P2-CA	0.131	1,700	5,900	0.119	560	1,900	off
P3-CA	0.146	1,500	5,300	0.157	430	1,500	off
P4-CA	0.0657	3,400	12,000	0.046	1,400	5,000	off
P5-CA	0.407	550	1,900	0.492	140	470	on
P6-CA	0.948	230	810	insufficient data (only up to day 30)	NE	NE	on
P7-CA	insufficient data (only up to day 7)	NE	NE	insufficient data (only up to day 7)	NE	NE	on
Median (d)	**0.28**	**1000**	**3600**	**0.16**	**430**	**1500**	

NE = Not evaluated
(a) MOEs rounded to 2 significant figures. Air concentrations based on actual measurements in DAS study.
(b) House number in study and location.
‘(c) MOE = NOAEL/dose, where Dose calculated as follows: dose (μg/kg/day) = air conc (μg/m^3) * inhalation rate (m^3/day) * hours per day in house/24 hours * 1/body weight (kg). Assumptions are as follows: respiratory volumes of 13.3, and 8.1 m^3/day for an adults and 1-6 yr old child (average of male and female), respectively (Exposure Factors Handbook 1997 p. 5-24), and body weights of 70 and 15 kg, respectively. In addition, it assumes that adults and children spend 16.4 and 20 hours per day at home, respectively (Exposure Factors Handbook 1997 p.15-17, 15-147).
(d) Median MOE based on central tendency of MOE values, and not calculated based on median air concentration.

Table A-2
Estimates of Post-Application Risks to Residents from Post Construction Termiticide Treatment Reflecting Risk Mitigation to 0.5% ai (a)

Home Type (b)	90- Day Incremental TWA			1 Year Incremental TWA			Comments/ Fan Status
	Air Concentration ($\mu g/m^3$)	MOE (c) (NOAEL= 0.1 mg/kg/day)		Air Concentration ($\mu g/m^3$)	MOE (c) (NOAEL= 0.03 mg/kg/day)		
		Child (1-6 yrs)	Adult		Child (1-6 yrs)	Adult	
Basement- Style Construction							
B1-KS	0.19	1,200	4,200	0.14	480	1,700	on
B2-KS	0.20	1,100	3,900	0.22	310	1,100	off
B3-DC	0.03	8,600	30,000	0.03	2,500	8,500	off
B4-DC	0.03	6,500	23,000	0.03	2,400	8,200	on
B5-GA	0.37	600	2,100	0.25	270	930	on
B6-GA	0.16	1,400	4,700	0.11	560	2,000	unknown
B7-MA	0.03	8,700	30,000	0.03	2,500	8,800	on
B8-MA	0.04	6,200	21,000	0.04	1,600	5,700	on
Median **(d)**	**0.1**	**3,800**	**13,000**	**0.07**	**1,100**	**3,800**	
Crawl Space-style Construction							
C1-GA	0.23	950	3,300	0.20	340	1,200	off, first 7 days set to 0
C2-GA	0.03	7,200	25,000	0.04	1,800	6,200	on
C3-TX	0.18	1,300	4,300	0.13	520	1,800	on
C4-TX	0.14	1,600	5,500	0.18	380	1,300	off, first 7 days set to 0
C5-GA	0.21	1,100	3,600	0.16	430	1,500	unknown
C6-GA	0.08	2,600	9,100	0.12	540	1,900	unknown
C7-TX	0.03	5,900	20,000	0.03	2,100	7,400	on, first 7 days set to 0
C8-TX	0.04	5,100	18,000	0.03	2,100	7,300	on
Median **(d)**	**0.11**	**2100**	**7,300**	**0.13**	**530**	**1,800**	
Slab type Construction							
S1-TX	0.15	1,500	5,200	0.17	390	1,400	on
S2-TX	0.10	2,200	7,500	0.13	510	1,800	off
S3-TX	0.11	2,000	6,900	0.11	590	2,000	on
S4-TX	0.10	2,200	7,500	0.09	760	2,600	off

Table A-2 Estimates of Post-Application Risks to Residents from Post Construction Termiticide Treatment Reflecting Risk Mitigation to 0.5% ai (a)							
Home Type (b)	90- Day Incremental TWA			1 Year Incremental TWA			Comments/ Fan Status
	Air Concentration ($\mu g/m^3$)	MOE (c) (NOAEL= 0.1 mg/kg/day)		Air Concentration ($\mu g/m^3$)	MOE (c) (NOAEL= 0.03 mg/kg/day)		
		Child (1-6 yrs)	Adult		Child (1-6 yrs)	Adult	
S5-TX	0.04	5,800	20,000	0.03	2,200	7,600	off, first 7 days set to 0
S6-TX	0.21	1,100	3,700	0.24	280	960	off, first 7 days set to 0
S7-TX	0.51	440	1,500	0.11	600	2,100	off
S8-TX	0.12	1,800	6,300	0.08	880	3,000	off
***Median* (d)**	**0.12**	**1,900**	**6,600**	**0.11**	**600**	**2,100**	
Plenum-style Construction							
P1-CA	0.36	610	2,100	0.13	500	1,700	---
P2-CA	0.08	2700	9,400	0.07	900	3,100	off
P3-CA	0.08	2700	9,500	0.09	760	2,600	off
P4-CA	0.03	6400	22,000	0.02	2700	9,500	off
P5-CA	0.20	1100	3,800	0.25	270	940	on
P6-CA	0.48	460	1,600	insufficient data (only up to day 30)	NE	NE	on
P7-CA	insufficient data (only up to day 7)	NE	NE	insufficient data (only up to day 7)	NE	NE	on
***Median* (d)**	**0.14**	**1900**	**6,600**	**0.09**	**760**	**2,600**	

NE = Not evaluated

(a) MOEs rounded to 2 significant figures. Air concentrations adjusted from 0.6-1.3% ai to 0.5% ai.

(b) House number in study and location.

‘(c) MOE = NOAEL/dose, where Dose calculated as follows: dose (μg/kg/day) = air conc ($\mu g/m^3$) * inhalation rate (m^3/day) * hours per day in house/24 hours * 1/body weight (kg). Assumptions are as follows: respiratory volumes of 13.3, and 8.1 m^3/day for an adults and 1-6 yr old child (average of male and female), respectively (Exposure Factors Handbook 1997 p. 5-24), and body weights of 70 and 15 kg, respectively. In addition, it assumes that adults and children spend 16.4 and 20 hours per day at home, respectively (Exposure Factors Handbook 1997 p.15-17, 15-147)

(d) Median MOE based on central tendency of MOE values, and not calculated based on median air concentration.